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NEWS

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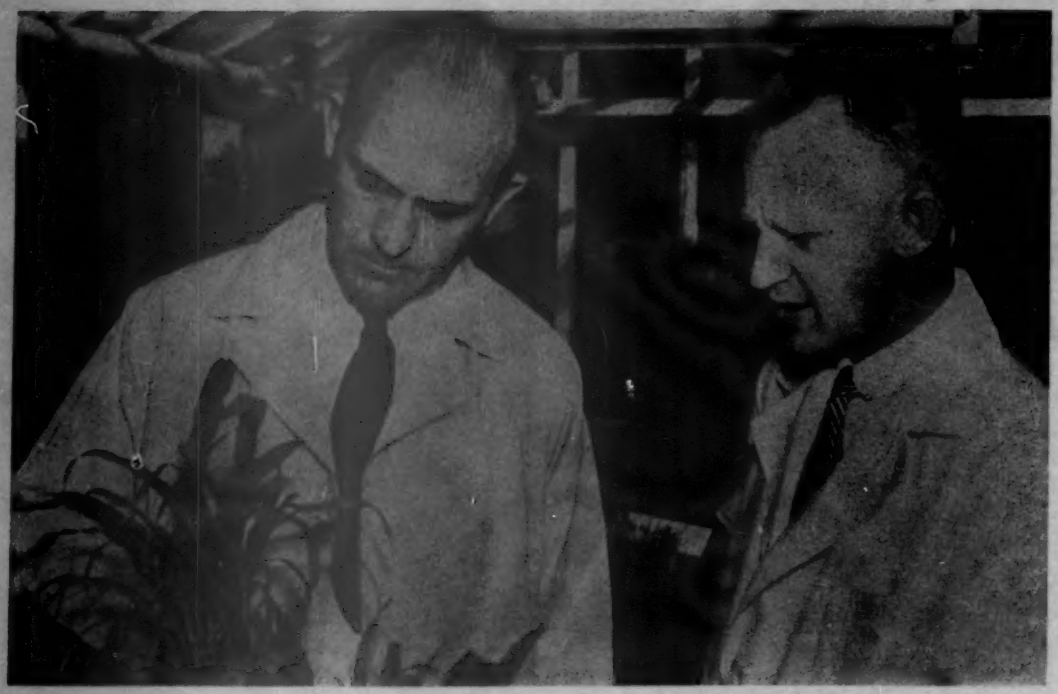

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ABSTRACTS OF PAPERS ACCEPTED FOR PRESENTATION AT THE FORTY-EIGHTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY CINCINNATI, OHIO, DECEMBER 6, 7, 8, 1956

Studies of certain nutritional requirements of Chloromycetin-resistant, Chloromycetin-susceptible, pathogenic, and nonpathogenic isolates of Pseudomonas solanacearum. ABO EL DAHAB, MOSTAFA, AND CARROLL E. COX. For 2 isolates of *Pseudomonas solanacearum*, 1 from tobacco and 1 from tomato, minimal inhibitory concentration of Chloromycetin (chloramphenicol) after 24 hours' incubation was 12–25 μg/ml and 6–12 μg/ml, respectively. Prolonged incubation with Chloromycetin permitted isolation of strains resistant to the antibiotic. Doubling the concentration of Chloromycetin at each subsequent transfer permitted step-wise increase of resistance to a maximum tolerance of 500 μg/ml. Pathogenic and nonpathogenic strains were isolated from Chloromycetin-susceptible, moderately resistant (50 μg/ml), and highly resistant (500 μg/ml) strains of both isolates. Chloromycetin resistance and pathogenicity were unrelated. The 6 strains of each isolate were tested on the following kinds of media: minimal + $(NH_4)_2SO_4$, minimal + vitamin-free casein hydrolysate, and minimal + single amino acids. There were no differences in nitrogen requirements of the pathogenic and nonpathogenic strains. Only the Chloromycetin-susceptible strain of both isolates and the moderately resistant strain of the tobacco isolate grew in ammonium sulfate medium. All strains grew well when only serine was present. Alanine substituted for serine with the highly resistant strains of both isolates, whereas proline, asparagine, or glutamine could be substituted for alanine or serine with the tomato strain.

Antidoting the fungitoxicity of copper. ADAM, ANGELOS V., AND DWIGHT POWELL. Experiments with spores of *Monilinia fructicola* (I) and *Stemphylium sarcinaeforme* (II) demonstrated that many metabolic agents caused an antidoting effect on the toxicity of copper sulfate. Amino acids were the most effective compounds tested: 39 of 46 tested caused detoxification. Spores of I and II that had been exposed to 16 ppm copper sulfate for 15 and 50 minutes, respectively, then washed and transferred to distilled water for 16 hours were completely inhibited. In contrast, normal germination occurred after spores were exposed to copper sulfate as above, then washed, and transferred to 500 ppm L-serine. Increasing the exposure time to the copper sulfate proportionately lessened the antidoting effect of the L-serine. After spores of I and II were exposed to copper sulfate for 2 and 3 hours, respectively, no antidoting resulted from the L-serine. Thus, after exposure to a lethal concentration of copper sulfate, power to germinate was restored by a nonlethal concentration of a reversing metabolite such as L-serine. It was postulated from these tests that the detoxification process was occurring inside the spore wall.

Etiology and control of poinsettia root and stem rot. ALEXANDER, PAUL M. Diseased poinsettias, obtained from commercial and University greenhouses, have been examined during the past 4 years. Of the isolates obtained from the diseased specimens, over 90 per cent were identified as *Rhizoctonia solani* Kühn; the remainder consisted of species of *Pythium*, *Fusarium*, *Penicillium*, *Thielaviopsis*, *Alternaria*, and *Trichoderma* and several isolates of unidentified bacteria. *R. solani* and a *Pythium* sp. were the only organisms found to be pathogenic to poinsettias (Barbara Ecke Supreme and Oak Leaf varieties). Control of *R. solani*, when poinsettias were in sand and in soil of high organic content, was attempted by drenching the sand or soil with fungicides. Captan (*N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide), Terrachlor (75 per cent pentachloronitrobenzene), and zineb (zinc ethylenebis[dithiocarbamate]) were effective as sand drenches but ineffective as soil drenches. Semesan (30 per cent 2 chloro-4-(hydroxymercuri) phenol) and Pano-Drench 4 (0.6 per cent cyano(methylmercuri) guanidine) were equally effective when used as either sand or soil drenches. Ferbam (ferric dimethyldithiocarbamate), when used as a sand drench, discolored the roots and was also ineffective when used as a soil drench.

Evidence of immunity from virus S in the potato variety Saco. ALFIERI, S. A., AND R. F. STOUFFER. In chloroplast-agglutination tests with antisera specific for potato virus S, no virus could be detected in any of 45 Saco plants grown from field-grown tubers. Five plants grown from Saco tubers grafted with plugs from infected tubers (U.S.D.A. seedling 41956 infected with virus S) also were free of virus S. No virus could be detected in any of 12 Saco plants grafted with infected scions of 41956; the reciprocals of these grafts also resulted in no transmission. Similar results were obtained in 20 tests in which the variety Canoga was used as the source of virus S. Serological tests for virus S were made 3 weeks after grafting; at this time, good union and good scion growth were evident in almost all plants. Ten hills of Saco were selected in the field; the leaves of these plants were dusted with Carborundum and rubbed with juice from infected 41956. These and adjacent noninoculated plants tested virus free over a 6-week period. Similar results were obtained when 10 Saco plants were similarly inoculated in greenhouse tests.

Symptoms of Golden Bantam corn inoculated with barley yellow-dwarf virus. ALLEN, THOMAS C., JR. Golden Bantam corn was inoculated with each of 6 different strains of barley yellow-dwarf virus (strains 1, 9, 10, 11, 13, and 14). The apple-grain aphid (*Rhopalosiphum prunifoliae* Fitch.) was used for all inoculations. The isolate of strain 11 from Arizona incited an interveinal streaking and purpling that started at the tips of the oldest leaves and progressed downward on such leaves. As the plant matured, the symptoms appeared progressively higher on the plant, eventually becoming evident on the newer leaves. Of 37 seedlings of Ferry Morse's Golden Bantam corn, all became infected in 2 greenhouse inoculation trials. An equal number of control seedlings fed upon by nonviruliferous apple-grain aphids developed no discoloration. Inoculations were made 10 days after planting. Only 1 of 10 seedlings of Germain's Golden Bantam corn purpled when inoculated with strain 11. No other strains incited any discoloration. No virus transfer attempts from discolored corn to corn, to barley, or to oats were successful.

Location of barley yellow-dwarf virus in plant tissue. ALLEN, THOMAS C., JR. The 3 methods used to locate the plant tissue that contains the barley yellow-dwarf virus indicated that the virus is in the phloem. Leaves upon which apple-grain aphids (*Rhopalosiphum prunifoliae* Fitch.) were feeding were sectioned (20μ) and stained with a combination of safranin and fast green. Stylets and stylet sheaths could be traced in the sections. Over 77 per cent of 1144 feeding tracks ended in the phloem, less than 1 per cent ended in the xylem, and approximately 22 per cent ended elsewhere. Experiments on virus movement produced erratic results, but the movement appeared to re-

semble most closely that which most workers associate with movement in phloem. When crown and leaf sections of Black Hulless barley were stained with Rawlins' modification of Bald's stain and with the Sakagushi stain, the phloem gave positive reactions.

Tar spot of annual Korean lespedeza. ALLISON, J. LEWIS. In North Carolina, annual Korean lespedeza (*Lespedeza stipulacea* Maxim.) is infected and severely defoliated by the tar spot fungus, *Phyllachora lespedezae* (Schw.) Sacc. Native species of lespedeza are known to be susceptible in southeastern United States, but this is the first report of its occurrence on introduced Korean lespedeza grown extensively as a hay and seed crop in this region. Damage has been most severe in breeding nurseries at Raleigh, but the disease is prevalent on Korean lespedeza throughout the state. Annual Kobe (*L. striata* (Thunb.) H. & A.) and perennial sericea lespedeza (*L. cuneata* (Dumont) Don) have not been attacked by the tar spot fungus. Two morphologically distinct stages of the fungus occur. The first arises from primary ascospore infections of early summer and consists of single perithecia containing typical 4-spored asci. Widespread secondary ascosporic infection results. From these infections, large flat sterile stromatic tar spots develop. After the fungus overwinters on defoliated leaves, perithecia develop sparingly in the stromata to provide the primary ascosporic inoculum.

Variation in germination of isolates of Phytophthora infestans. ANDERSON, C. D., AND H. L. BARNETT. Tests of 63 isolates of *P. infestans* indicate that the percentage of indirect germination of sporangia is an isolate characteristic. Indirect germination of the isolates ranged from 2 to 91 per cent after 2 hours in distilled water at 10°C and from 27 to 97 per cent after 8 hours. Direct germination under these conditions was negligible. Extensive germination studies were made with sporangia 5–9 days old from single-zoospore cultures of 4 isolates and from multispore cultures of 2 isolates. Variation due to age of sporangia was 4 per cent in the high-germination isolates and as great as 22 per cent in the low-germination isolates. Neither percentage nor rate of indirect germination could be correlated with the pathogenic races represented by the isolates. Manipulation of environmental factors, such as aeration and washing of sporangia, was only partially successful in increasing germination. Choice of isolate and selection of sporangia at the right age seem to be the most reliable means of obtaining high germination.

Celery yellows Fusarium causes wilt of peas. ARMSTRONG, G. M., AND J. K. ARMSTRONG. Plants of 9 varieties of peas (*Pisum sativum* L.) and 4 varieties of celery (*Apium graveolens* L. var. *dulce* DC.) were inoculated in greenhouse tests with single-spore and mass cultures of 9 isolates of the pea wilt Fusarium (4 of race 1 and 5 of race 2) and of 12 isolates of the celery yellows Fusarium. The isolates from pea caused wilt of pea only, but those from celery caused typical symptoms on both celery and pea. Peas inoculated with the celery Fusarium showed symptoms of wilt later than those inoculated with the pea Fusarium and, in general, were somewhat more resistant to the celery organism, although 83–100 per cent of Alaska and Thos. Laxton plants were eventually killed by this organism. Isolations from these diseased pea plants were pathogenic on celery. The celery isolates lost pathogenicity on peas, as shown by the wilting of 100, 80, and 50 per cent, respectively, of Thos. Laxton pea plants in successive tests during 1 year, but no loss of virulence of the same isolates was noted on the susceptible Golden Self-Blanching variety of celery.

The water-soak seed treatment for the control of barley loose smut. ARNY, D. C. Tests with the water-soak seed treatment to control loose smut (incited by *Ustilago nuda* (Jens.) Rostr.) have been made on a number of barley samples from Wisconsin and the north central United States over a 3-year period. Loose smut was satisfactorily controlled although not completely eliminated. The effect of the soaking treatment on germination was greater in Kindred than in other varieties. Seed from certain locations gave consistently low germinations following the soak treatment. A "synthetic" steep liquid was made up with formic, acetic, *n*-butyric, and succinic acids. When naturally infected seed was soaked in the synthetic at a low temperature, some control of loose smut was obtained. With artificially inoculated seed, the synthetic had little effect on loose smut. The soak treatment was only partially effective when artificially inoculated seed was used. The presence of additional seed in the soak water did not increase the effectiveness in most cases.

Studies of soybean infection by the stem canker fungus. ATHOW, KIRK L. Observations on time and place of natural infection by the soybean stem canker fungus, *Diaporthe phaseolorum* var. *caulivora*, have been made for 8 years. In date-of-planting studies in which plantings were made at approximately 5 weekly intervals, stem lesions never were observed before the plants were 62 days old, irrespective of the date this age was reached. The earliest observable infection in 31 of the 40 plantings was noted on plants 70–80 days old; however, artificial inoculation of plants 28 and 35 days old resulted in 50 and 85 per cent infection, respectively. It was demonstrated that practically all natural infection takes place through leaves. The exact site of infection has not been determined, but observations indicate that it is either the leaf blade or the juncture of leaflets and petiole. The growth of the fungus from this junction through the petiole into the main stem has been followed by isolations from different places on petioles in various stages of infection. Removal of the first 6 trifoliate leaves before the plants were 58 days old resulted in no infection. In adjacent check rows, from which no leaves were removed, as high as 36 per cent of the plants were infected.

Inheritance studies on northern and southern anthracnose of red clover. ATHOW, KIRK L., AND RALPH L. DAVIS. Red clover plants of the varieties Dollard and Purdue, resistant to *Kabatiella caulivora* (cause of northern anthracnose), and plants of the variety Kenland, resistant to *Colletotrichum trifolii* (cause of southern anthracnose), were selected after artificial inoculation in the greenhouse. The plants resistant to northern anthracnose were crossed with those resistant to southern anthracnose in an attempt to combine the resistances. Approximately 9 per cent of the F_2 progeny were resistant to both diseases, suggesting that resistance to each disease is recessive. This led to a study of the inheritance of resistance. In a cross of plants resistant to southern anthracnose with plants susceptible to this disease, the F_2 progeny segregated in a ratio of 3 susceptible to 1 resistant, indicating that resistance is conditioned by a single recessive factor. The F_2 segregation in crosses of plants resistant to northern anthracnose with plants susceptible to this disease did not fit a 3:1 ratio; however, the F_2 progeny from 13 of 15 F_1 plants in one cross and from 13 of 16 F_1 plants in another cross did segregate in a ratio of 3 susceptible to 1 resistant, indicating a single-factor segregation.

Potato virus S. BAGNALL, R. H., AND R. H. LARSON. Potato virus S was shown to be very widespread in North American potatoes. Symptoms incited on potatoes usually were so slight that they passed for normal effects of maturity. Virus S could be distinguished from other potato viruses by serological tests and by the reactions of a number of differential test-plants. *Chenopodium album*, *Cyamopsis tetragonoloba*, *Nicotiana debneyi*, *Saracha umbellata*, and *Solanum rostratum* developed characteristic symptoms when infected by sap inoculation with virus S

and held at 20° C. *Physalis philadelphica, Datura metel,* and *Solanum villosum* were symptomless hosts, whereas *Capsicum annuum, Lycopersicum esculentum, Nicotiana tabacum* var. Havana 38, *N. glutinosa, Physalis floridana,* and *Solanum melongena* were not infected. Virus S survived 10 minutes' heating at 60° C, and 6 days' aging at 20°C. No insect vector is known. Strains of virus S have been encountered. These are closely related serologically but differ slightly with respect to reactions incited on test plants, including potato.

Potato virus M. Bagnall, R. H., and R. H. Larson. The name "potato virus M" has been given to the virus component which, in addition to virus S and virus X, was isolated from "interveinal mosaic" diseased Irish Cobbler potatoes. Virus M was isolated from the complex by passage through potato seedling 41956 to eliminate virus X and thence through *Datura metel* from upper leaves of which virus M alone was recovered. At 20° C, *Cyamopsis tetragonaloba, D. metel, Nicotiana debneyi, Solanum rostratum,* and *Vigna sinensis* developed symptoms when inoculated by rubbing with virus M. *Lycopersicum esculentum, Solanum melongena,* and *S. villosum* were symptomless hosts, whereas *Capsicum annuum, Nicotiana tabacum, N. glutinosa,* and *Physalis floridana* were not infected. Virus M infected *P. philadelphica* but did not become fully systemic as did virus S. Virus M survived 10 minutes at 65° C and 2 days at 20° C. Cross-precipitin tests showed serological relationship between virus M and virus S, but the factor in common was small and could be eliminated by cross absorption or by dilution of the antisera. Serological and differential host tests indicated the presence of 2 viruses, one resembling virus M and the other resembling virus S, in each of the following sources: "leafrolling mosaic" Green Mountain and "healthy" King Edward and Fortuna potatoes.

Comparative studies on the resistance of two carnation varieties to Fusarium stem rot. Baker, Ralph. Miller's Yellow and William Sim varieties of carnation were compared to determine their resistance to *Fusarium roseum* f. *cerealis.* When these varieties were inoculated immediately after "striking" or transplanting and later rated for disease severity, no consistent differences in susceptibility were noted. In further tests, rooted cuttings of the 2 varieties were inoculated at intervals from 0–24 days after transplanting. Miller's Yellow was still susceptible 24 days after transplanting, whereas William Sim was moderately resistant 4 days after transplanting. This seems to be the principal difference in the susceptibility of these 2 varieties and may be attributable to different disease potentials (as defined by Grainger) of the 2 varieties.

A routine assay method using trichloroacetic acid for estimating tobacco mosaic virus concentration. Bancroft, John B., and Roy W. Curtis. An assay method designed for routine use in a screening program for inhibitors of plant virus multiplication is relatively rapid, does not require an ultracentrifuge, is quite selective for virus but not for host products that absorb at 260 mμ, and gives results comparable to those obtained by standard methods. Two ml of 2 M trichloroacetic acid was added to 4-ml samples of cleared sap at room temperature. The samples were allowed to stand for 5 minutes and were then centrifuged at 2000G after which the supernatants were discarded and the tubes drained. Six ml of 0.3 M trichloroacetic acid was added to the tubes, and the samples were hydrolyzed for 15 minutes at 90°C and then cooled and filtered. The absorption ratio (maximum absorption at 260 mμ/minimum absorption at 230 mμ) was 2.6, and Beer's law was applicable. The maximum standard deviation found in any one experiment was ± 7.6 per cent. Experiments involving comparison of results by this method to others indicated that the hydrolysates contained material closely associated with, and probably a part of, tobacco mosaic virus.

The severity and control of angular leaf spot of beans in Colombia. Barros, O., R. Cardenosa, and R. L. Skiles. In the past 2 years, angular leaf spot of pinto beans has become severe in Colombia, especially in the Cauca Valley. Yields of a new variety, Algarrobo, released early in 1954, were estimated to be 30 per cent less than normal in the latter part of 1955, solely because of this disease. Before 1954, the disease was practically unknown in the Cauca Valley, although the older commercial varieties Panameno and Sangretoro were equally as susceptible as, or more susceptible than, the new one when the disease became epidemic. In fungicide tests made in 1955, untreated plots of Algarrobo, Panameno, and Sangretoro yielded only 80, 68, and 68 per cent, respectively, as much as those treated with zineb. Equipment for fungicide application is not readily available in Colombia, therefore varieties were tested for resistance. Several highly resistant native and foreign varieties of no commercial value were found; in most simple crosses, resistance appeared to be recessive and controlled by 2 or 3 independent factors. In a very few crosses, resistance was dominant. Two advanced-generation lines with much greater resistance than that of the older varieties are being increased, and 1 probably will be released early in 1957.

Susceptibility of non-oak species to Endoconidiophora fagacearum. Bart, George J. Fifteen non-oak species of trees, 3–10 years old, were inoculated with conidia of *Endoconidiophora fagacearum* Bretz. Symptoms similar to oak wilt developed only on Malus species. Leaf discoloration, curling, and defoliation appeared on Jonathan and Delicious apple trees 14 days after inoculation. Discoloration of leaves and xylem and ultimate death occurred more rapidly in Jonathan than in Delicious apple. One year after inoculation, the pathogen was readily recovered from stem and root tips of the Jonathan trees. *E. fagacearum* also persisted and spread in the following trees: ash, beech, dogwood, hop-hornbeam, hickory, sassafras, sourwood, and wild cherry. The pathogen was recovered a maximum distance of 36 in. from the site of inoculation in sassafras after 995 days and 30 in. in hop-hornbeam after 250 days. Discoloration of the xylem was most severe in sassafras and extended 60 in. from the site of inoculation. Spread of *E. fagacearum* did not exceed 15 in. from the inoculation site in the remaining inoculated trees. The fungus could not be recovered from aspen, blue beech, elm, locust, maple, or walnut trees.

Chemical inhibition of springwood development in relation to infection and symptoms of the Dutch elm disease. Beckman, C. H., and F. L. Howard. Thiazolylmercaptoacetates (TMA) have shown a capacity to reduce wilts caused by pathogens. Their action was studied in laboratory and field experiments. In growth tests, 5 ppm of indole acetic acid (IAA) was neutralized by 500 ppm sodium 4,5-dimethyl-TMA and related compounds. These results indicate a growth-inhibitor activity. Sodium 4,5-dimethyl-TMA was dry-packed into trunk bore-holes of 45 elms with diameters of 1–4 in. (4 g/in. diameter) during bud swelling and bud break (May 2–17). In trees packed 1 or 3 times, springwood was reduced up to 80 per cent on June 13. Fewer and incomplete rings of vessels were present. Single and 3 weekly applications reduced infections by *Ceratostomella ulmi* by 63 and 100 per cent, respectively, in early inoculations (June 5) when springwood was limited, but failed to reduce infection following reinoculation (June 20) when springwood was better developed. Once infected, treated trees showed wilt comparable to that in untreated trees. Treatment (June 1–14) after considerable springwood had been formed did not reduce infection or symptom development following inoculation on June 20. Results suggest that inhibition of

springwood development by thiazolylmercaptoacetates limits establishment of the pathogen.

Gamma radiation for possible control of postharvest diseases of lemons and oranges. BERAHA, LOUIS, G. B. RAMSEY, M. A. SMITH, AND W. R. WRIGHT. Gamma radiation facilities for research on the control of postharvest diseases have been made available at the Argonne National Laboratory through contract with the Army Quartermaster Food and Container Institute. The gamma source, consisting of spent fuel elements from the Materials Testing Reactor at Arco, Idaho, is maintained with a minimal flux of 1×10^6 rep/hr. Dosages are attained by varying exposure time and proximity to source. Experiments with artificially inoculated lemons and oranges have indicated the possibility of control of *Penicillium digitatum* and *P. italicum* following irradiation between 2×10^5 rep and 1×10^5 rep. The nature of control apparently is not sterilization, since the irradiation dosages required for complete kill of the pathogen produce textural and skin-color abnormalities of the fruits. Safe and effective dosages, which prolong the period lemons and oranges can be held without spoilage, either partially inactivate the pathogen or extend the latent period of infection. The length of holding without incidence of infection or visible radiation injury bears a direct relation to the dose received, to the temperature of storage, to the age of infection, to the nature of the suscept, and to the organism involved.

Gamma radiation for possible control of postharvest diseases of apples, strawberries, grapes, and peaches. BERAHA, LOUIS, G. B. RAMSEY, M. A. SMITH, AND W. R. WRIGHT. Jonathan apples inoculated with *Penicillium expansum* and incubated 24 or 96 hours prior to irradiation required a minimal gamma ray dosage of 1×10^5 rep to delay or to suppress progress of infection when held for 6 days at 70–75°F. When the fruit was stored 10 days, a minimal dosage of 2×10^5 rep was necessary. Neither dosage produced visible radiation injury to apples. Gamma radiation at approximately 2×10^5 rep, either alone or in combination with refrigeration, markedly prolonged storage life of noninoculated strawberries by delaying development of both *Rhizopus nigricans* and *Botrytis cinerea* without visible radiation damage. The growth of *B. cinerea* in grapes after inoculation, as evidenced by the appearance of rot, was inversely proportional to the dosage of irradiation within the range of 5×10^4 to 3×10^5 rep. At 1×10^6 rep and 5×10^5 rep, no rot developed within 10 days after inoculation. Peaches inoculated with *Monilinia fructicola*, irradiated at a dosage range of 2×10^5 to 3×10^5 rep, and held at room temperature for 10 days did not become infected. Under the same conditions, radiation in the range of 2.5×10^5 to 3×10^5 controlled *R. nigricans* without radiation injury. Inoculations in each case produced severe infection in nonirradiated controls within 5 days.

Pratylenchus penetrans in clonal apple stocks. BOSHER, J. E., AND W. NEWTON. Dissemination of *Pratylenchus penetrans* in the roots of apple stocks is favoured by the use of layering methods used in propagating clonal stocks. Pratylenchus was found in 83–100 per cent of maiden stocks of East Malling VII and IX taken from infested layering beds. In contrast, only 23 per cent of seedling stocks were infected; however, precise information was not available upon the amount of infestation in the soils where the seedlings were grown. Conspicuous root injury and reduced growth in 2-year-old stocks were associated with populations of Pratylenchus exceeding 80 per g of roots. Soil fumigation by injection of Nemagon (1,2-dibromo-3-chloropropane) at rates of 10–40 gal. per acre in the root-zone of 2-year-old apple stocks during the dormant growth period in early November or during active growth in June significantly reduced total nematode populations but did not completely eradicate Pratylenchus. The highest dosage rate, 40 gal. per acre, applied in the dormant season, caused only slight yellowing of the foliage during the year following treatment, but dosages of 15 or 20 gal. per acre applied during active growth in June caused severe yellowing of the foliage and reduced plant growth.

The role of tobacco mosaic virus in abnormal ripening disorders of tomato. BOYLE, JOHN S., AND DAVID C. WHARTON. The role of 9 isolates of tobacco mosaic virus (TMV) in the development of internal browning (IB) of tomato was determined. Final records on incidence and severity were taken by harvesting and cutting all fruit. Each isolate was tested on 40 plants of the variety Rutgers; 3 were tested also on the varieties Kopiah and Geneva. The incidence of IB in the Rutgers variety inoculated August 7 and cut 20–24 days later varied with the isolate and ranged from 97.5 to 0 per cent. Fruits from 40 noninoculated control plants were all normal. In a replicated test, with plants inoculated August 23 and harvested 18–28 days later, the results were essentially the same with the incidence of IB ranging from 100 to 2.5 per cent. Two of 40 noninoculated control plants produced IB fruit. The incidence of IB in the varieties Kopiah and Geneva inoculated August 7 ranged from 72.5 to 7.5 per cent and from 95.0 to 2.6 per cent, respectively. One of 40 noninoculated Kopiah control plants produced IB fruit. Fruits from 38 plants of the variety Geneva were all normal. No abnormal ripening other than IB was induced by any of the isolates of TMV tested.

Pigmentation and host range as species characters in Helminthosporium. BRAVERMAN, S. W. Host range and crude pigment extracts of 4 isolates of each of 9 species of *Helminthosporium* were investigated as possible characters for species distinction. In Czapek-Dox medium, *H. erythrospilum* produced a faint pink pigment; *H. siccans*, pink; *H. dictyoides*, faint yellow; *H. dictyoides* var. *phlei*, faint orange; *H. teres* and *H. gramineum*, orange; and *H. avenae*, red-orange. *Pyrenophora bromi* and *Pleospora phaecomes* produced no pigments. The percentage transmittance at wave-length intervals of 25 mμ in the visible spectrum was obtained with a spectrophotometer. In inoculations, *H. siccans* was pathogenic to *Lolium* spp. and *Festuca* spp.; *H. dictyoides* to *Festuca* spp.; *H. dictyoides* var. *phlei* to *Phleum pratense*; *H. erythrospilum* to *Agrostis alba*; *H. avenae* to *Avena sativa*, *Arrhenatherum elatior*, and *Dactylis glomerata*; *H. teres* and *H. gramineum* to *Hordeum vulgare*; *Pyrenophora bromi* to *Bromus inermis*; and *Pleospora phaecomes* to *Dactylis glomerata*. Results indicated that the species studied, with the possible exception of *H. teres and H. gramineum*, can be differentiated through use of pigmentation and host-range characteristics.

Studies of the effect of field blends of oat varieties on stem rust losses. BROWNING, J. ARTIE. That varietal diversification and especially that field blends of varieties might reduce losses from diseases has been suggested by numerous investigators, but very few quantitative data collected under more or less controlled disease conditions are available. The existence of genes conditioning resistance to oat stem rust and of races of the oat stem rust fungus make oats ideally suited for supplying such data. The oat varieties Clintland (susceptible to race 7) and Mo. 0-205 (resistant to race 7) were grown in pure stands and in 50-50 mixtures in replicated yield trials and subjected to an induced epiphytotic of race 7. In 1954, Clintland yielded 28 bushels/acre; Mo. 0-205, 48; and the mixture, 45. Thus the mixture yielded 7 bushels/acre above the average of the yields of the component varieties when grown in pure stands. In 1955, Clintland yielded 82 bushels/acre; Mo. 0-205, 137; and the mixture, 124 (14.5 bushels/acre above the average of the 2 varieties grown separately). Data on kernel size and weight corroborated the yield data. Much

less rust developed on Clintland in the field blend than in pure stands. In 1955, the stiff-strawed Clintland supported Mo. 0-205 in the mixed plantings, whereas Mo. 0-205 lodged in pure stands.

Cephalosporium gramineum on wheat in Washington. BRUEHL, G. W., AND J. W. STROBEL. Wheat stripe disease was observed on *Dactylis glomerata* and on wheat west of the Cascades, on wheat in Klickitat County and in the eastern Palouse region, and on wheat, *Bromus marginatus*, and *Elymus glaucus* near the Blue Mountains. It was most prevalent in cool, moist sites. The fungus grows slowly at 7°C and fastest at 20°C on potato-dextrose agar. No measurable growth occurs at 30°. Sporulation is profuse from 7° to 20°C, moderate at 27°, sparse at 30°. Spores germinate from 5° to 30°C., inclusive. Primary conidia on the moist surface of the medium average 6.7μ in length and are uninucleate. Aerial conidia average 4.2μ. Secondary budded conidia are smaller than primary conidia. Infection can occur in underground parts, and root injury increases infection. The pathogen invades all aboveground parts, including caryopses, rachis, and awns, although relatively few seeds are infested. The fungus survived in dry straw held in the laboratory for 1 year. Some winter wheats inoculated hypodermically blighted prematurely, with white heads; in others, the heads remained alive but produced few and shrivelled kernels. Columbia appeared quite resistant. Twenty-nine species in 16 genera of grasses became infected when inoculated in a preliminary host-range trial.

Pollen transmission of elm mosaic virus. CALLAHAN, KEMPER L. In 1954, the seed-transmitted elm mosaic virus was found in pollen collected from an infected tree. To determine whether the virus could be pollen transmitted, 4 types of pollinations were made between healthy (H) and infected (I) parents (H♀ × H♂, H♀ × I♂, I♀ × I♂, and I♀ × H♂). Branches of each parent were forced to flower in cans of water in the greenhouse. Pollinations were made at postanthesis with a pollen gun. Each of the 2432 resulting seedlings was tested for virus by inoculations to Havana 38 tobacco. None of the 336 seedlings obtained from healthy parents was infected. Forty-eight per cent of the 569 seedlings obtained from the pollination of infected pistils with infected pollen were infected. An average of 30.5 per cent of 1523 seedlings obtained from 4 lots of crosses between healthy pistils and infected pollen was infected. Only 4 seedlings were obtained from the cross between infected pistils and healthy pollen; 3 of these were infected. Some infected seedlings expressed symptoms, but others were symptomless. Thus the elm mosaic virus was found to be pollen transmitted.

Prunus host range of elm mosaic virus. CALLAHAN, KEMPER L., AND J. DUAIN MOORE. In 1954, Moore and Varney reported that elm mosaic virus incited a rosetting disease of peach. In further host-range studies, buds from diseased elm were used to inoculate 28 species and varieties of Prunus. Two chip buds were used to inoculate each tree, and all inoculations were made at bud break. All experiments were carried out in the greenhouse. As each tree broke dormancy the following year, it was tested for virus by inoculations to Havana 38 tobacco. The virus was recovered from 14 of the 28 sorts tested. Symptoms were not observed until the year following inoculation, and then only on 13 of the 28 sorts. Yellowing and twisting of the leaf lamina were the most common symptoms; these were observed on Dunbar plum, Lambert sweet cherry, and others. Line pattern was observed on pin cherry, black cherry, Burbank plum, and Napoleon sweet cherry. Mottling and vein clearing developed on mahaleb. Symptoms were not expressed by Kwanzan or Shiro-fugen, nor was virus recovered from them. English Morello, Montmorency, and western sandcherry were found to be symptomless carriers of elm mosaic virus. Thus 17 species and varieties of Prunus were found to be susceptible to elm mosaic virus.

Lysis of fungi by Streptomyces isolates and fungicides. CARTER, H. PAUL, AND JOHN L. LOCKWOOD. Zones of lysed mycelium were produced around Streptomyces colonies that developed when soil suspensions were sprayed on agar media containing cultures of the following fungi: *Glomerella cingulata*, *Helminthosporium sativum*, *Colletotrichum circinans*, *Cladosporium cucumerinum*, *Fusarium oxysporum* f. *lycopersici*, *Rhizoctonia solani*, *Alternaria solani*, *Colletotrichum lagenarium*, and *Verticillium albo-atrum*. Lytic zones were most abundant and distinct with *G. cingulata*. No lytic microorganisms developed when *Fusarium solani*, *Pythium aphanidermatum*, or *Saccharomyces cerevisiae* were used as test fungi. Media supporting appressed colonies without abundant aerial mycelium were most favorable for production of lytic zones. Mycelium of *G. cingulata* growing in a liquid medium was lysed when Acti-dione (cycloheximide) or Streptomyces isolate 55 was added to cultures. Several fungicides, including antibiotics, lysed mycelium of this fungus on agar. Lytic zones produced by Streptomyces isolates were usually clearer than those produced by fungicides, and some isolates produced zones entirely free of mycelium of *G. cingulata*. Streptomyces isolates lysed both living mycelium and mycelium killed by heat or chloroform, whereas fungicides lysed only living mycelium.

Reaction of species of Nicotiana to species of root-knot nematodes. CHAPMAN, R. A. Species of *Nicotiana* were raised in pots of soil infested with single species of *Meloidogyne* in a greenhouse. Galls and egg-masses were produced by *M. incognita*, *M. hapla*, *M. arenaria*, and *M. javanica* in *N. tabacum*, *N. trigonophylla*, *N. palmeri*, *N. suaveolens*, *N. gossei*, *N. goodspeedii*, and *N. occidentalis*; by *M. incognita*, *M. hapla*, and *M. javanica* in *N. rotundifolia*; by *M. incognita* and *M. hapla* in *N. paniculata*, *N. rustica*, *N. tomentosiformis*, *N. glutinosa*, *N. sylvestris*, *N. longiflora*, *N. stocktonii*, *N. nesophila*, *N. panciflora*, *N. bigelovii*, *N. exigua*, and *N. debneyi*; by *M. arenaria* and *M. javanica* in *N. benevidesii*, *N. cordifolia*, *N. undulata*, *N. clevelandii*, *N. nudicaulis*, and *N. maritima*; by *M. hapla* and *M. javanica* in *N. glauca* and *N. megalosiphon*; by *M. hapla* and *M. arenaria* in *N. otophora*; and by *M. javanica* in *N. benthamiana*. Galls but no egg-masses were produced by *M. incognita* and *M. arenaria* in *N. glauca* and *N. megalosiphon*; by *M. arenaria* and *M. javanica* in *N. repanda* and *N. exigua*; by *M. javanica* in *N. optophora*; by *M. arenaria* in *N. longiflora*; and by *M. hapla* in *N. nudicaulis*. No galls or egg-masses were produced by *M. incognita* in *N. otophora* and *N. nudicaulis*.

The seedling reaction of four hull-less barley varieties to penetration and infection by Ustilago hordei. CHATTERJEE, PARUL, AND RICHARD L. KIESLING. Seedlings of 4 hull-less barley varieties, Nepal, Excelsior, Lompa, and Brachytic, were inoculated with spores of race 6 and with an Alaskan isolate of *U. hordei*. Pericarps of the 4 varieties shielded the elongating coleoptiles from contact with the germinating spores and were removed before inoculation. Spore germination and penetration of the coleoptiles by the 2 isolates of *U. hordei* were similar on all 4 varieties. After penetration, sheaths formed around and/or host cells collapsed ahead of the pentrating hyphae in the coleoptiles of all 4 varieties inoculated with race 6 and of Lompa and Brachytic inoculated with the Alaskan isolate. Coleoptiles mechanically wounded to simulate penetration failed to produce sheaths around the injured areas. The resistance of Lompa seedlings to the establishment of the Alaskan isolate of *U. hordei* was decreased when inoculated seedlings were grown on media containing L-glutamic, L-leucine, DL-phenyalanine, and L-proline. The susceptible reaction of Excelsior to the Alaskan isolate was not altered by these treatments with amino acids.

Methods for inoculating barley and oats with seedling-infecting smut fungi. CHEREWICK, W. J. A method simulating natural inoculation of coarse grains with seedling-infecting smut fungi was developed at Winnipeg. A spore suspension is poured into a Waring Blendor fitted with dull noncutting blades. The motor is started and the seed then dumped into the suspension and churned for 15–30 seconds, depending on toughness of the hulls. After draining, the seed is dried slowly to a moisture level at which it will not germinate or become mouldy and is then stored in paper packets in a cool, damp place for 1 to several weeks. This method of inoculation has resulted in 80–100 per cent infection in susceptible varieties of barley and oats. In a study of the genetics of the smut fungi, it was found that injecting seedlings in the 3- or 4-leaf stage with sporidial suspensions of monosporidial lines is the most effective method of inoculation. Compatible monosporidial lines were combined in 10 ml of potato-sugar water (50 per cent water and 2 per cent sucrose) in test tubes and cultured for 2 days in an intermittent shaker. This suspension was then injected with a hypodermic needle into seedlings just above the growing point. The inoculated plants must be grown under conditions of light and temperature that will require at least 6 weeks from the inoculation to heading of the plants.

A new disease of citrus trees in Florida. CHILDS, J. F. L. In 4 widely separated locations in Florida, a new disease has been found attacking the below-ground parts of 2- to 5-year-old citrus trees on well-drained sandy land recently cleared of turkey oak (*Quercus laevis*). The disease is characterized by the formation of soil-and-mycelium incrustations up to ¼ in. thick and of rhizomorphs on the below-ground parts of the citrus trees and on oak roots occasionally found in contact with them. Rough lemon (*Citrus limon*), sweet orange (*C. senensis*) and Rusk citrange (*C. sinensis* × *Poncirus trifoliata*) rootstocks have been attacked. Mycelial fans were not found. One fungus species has been isolated consistently from citrus roots, but spores or rhizomorphs were not produced on potato-dextrose, prune-extract, or malt-extract agar media. The binucleate mycelium of these isolates suggests that the causal agent may be a basidiomycete. Two inoculation attempts with these isolates failed.

The relation of temperature to disease development by Helminthosporium sativum on barley. CLARK, R. V., AND J. G. DICKSON. The influence of temperature on the development of leaf blotch incited by *H. sativum* was compared with that of the development of seedling blight and root rot. Six isolates of the fungus and 6 varieties of barley were used. Seedlings were grown in controlled temperature houses and in temperature tanks. Leaf infection was obtained by spraying with spore-mycelial suspensions. Root rot and seedling blight were initiated by adding a uniform sand-cornmeal inoculum to the medium in which the kernels were planted. Maximum development of leaf lesions and necrosis occurred at 28°C, with rapid development at 24° and less at 20° and 16°. Seedling blight and root rot developed severely at all temperatures used, which ranged from 8° to 28°C. Maximum development usually occurred at 20°. Considerable shifting in the reaction of the isolates and in the response of the varieties occurred within the replicates of an experiment and between experiments in the development of seedling blight and root rot.

Comparative respiratory metabolism of spores and mycelium. COCHRANE, VINCENT W. When resting cells or conidia of *Fusarium solani* or of certain other fungi oxidize specifically labeled glucose, the radiochemical yields from the 1 and the 6 positions suggest that spore respiration differs qualitatively from mycelial respiration. In other organisms, e.g. *Streptomyces scabies* and *Myrothecium verrucaria*, there is no difference between spores and mycelium in this regard. Endogenous respiratory quotients of conidia vary from 1 species to another and do not yield substantial information on the chemical nature of the endogenous reserves. When uniformly labeled glucose is oxidized by conidia or by resting mycelium, the radiochemical yield may differ sharply from the manometric yield of carbon dioxide; it appears that the substrate influences the rate of utilization of endogenous reserves. Comparison of radiochemical and manometric yields indicates that exogenous substrate may suppress, accelerate, or fail to affect the endogenous carbon dioxide production in different species and in different cell types.

Systemic factors in Fusarium wilt of tomato. COLLINS, R. P., AND R. P. SCHEFFER. As early as 2 days after inoculation with *Fusarium oxysporum* f. *lycopersici*, leaves from infected plants had higher respiration than did disease-free controls. Higher respiration rates continued until plants showed advanced symptoms. These comparative results were on a dry-weight basis and were obtained with leaf discs and the Warburg technique. Infection also caused increased permeability to electrolytes as early as 6 days after inoculation, as determined by conductivity of leaf leachings. Since leaves were not invaded by the fungus, findings demonstrate systemic toxemia. Nothing indicated that theoretical toxins were "wilt toxins" or necrotic agents, since wilting is correlated with vascular dysfunction and necrosis was seldom observed in leaf tissue. Attempts were made to determine if ethylene, a known vivotoxin, affects permeability and other reactions. Negative results were obtained to date in experiments to determine effects of ethylene on pectin, pectic enzymes, transpiration rates, and permeability to electrolytes. Ethylene hastened disease development when introduced in solution into inoculated cuttings and caused cuttings of similarly treated resistant plants to become diseased.

Chemical control of melting out of Kentucky bluegrass. COUCH, HOUSTON B., AND HERBERT COLE, JR. The 1956 growing season in Pennsylvania was marked by severe outbreaks of the melting out disease of Kentucky bluegrass, incited by *Helminthosporium vagans* Drechls. At the peak of disease development, many stands of bluegrass were either entirely killed or rendered so undesirable that it was necessary that they be re-established. In replicated large-scale field tests, highly significant reductions in intensity of the leaf spot phase of the disease were given by the following fungicides and insecticides: Acti-dione (cycloheximide), Kromad (5 per cent cadmium sebacate, 5 per cent potassium chromate, 1 per cent malachite green, 0.5 per cent auramine, and 16 per cent tetramethylthiuram disulfide), Omadine (the disulfide derivative of 2-pyridinethione-1-oxide, 50 per cent), Captan 50-W (50 per cent *N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide) and Terramycin (oxytetracycline). A further test of the efficacy of these materials was made by taking clipping weights simultaneously with the leaf spot samples. These showed that Acti-dione caused a temporary retardation in growth, whereas Omadine, Kromad, and Captan 50-W brought about significant increases in yields per plot.

Additive effect of Agri-mycin and copper in the control of bacterial spot of pepper. COX, R. S. Agri-mycin (15 per cent streptomycin sulfate, 1.5 per cent oxytetracycline) and Copper A (calcium copper chloride) each provided appreciable degrees of control of bacterial spot (caused by *Xanthomonas vesicatoria*) of pepper in 8 field trials over the period 1954–56 (materials applied on a 5-day schedule). Usually, Agri-mycin appeared to be more effective than Copper A, but occasionally the opposite was true; the 2 used in mixture were more effective than either used alone. In 1 test, disease severity (0-11 scale) in untreated plots and in those sprayed with Agri-mycin at 100, 200, and 400 ppm, with Copper A (4 lb./100 gal.) and with Copper A (4/100) in mixture with Agri-mycin at

100, 200, and 400 ppm was 6.0, 2.9, 2.5, 1.5, 4.2, 2.1, 1.5, and 1.1, respectively. In another test, disease severity (0-11) and yield (lb./plot), respectively from untreated plots and from those sprayed with Agri-mycin at 100, 200, 400 ppm, with Copper A (4/100), and with Copper A (4/100) plus Agri-mycin at 100 and 200 ppm were, respectively, 7.0 and 20; 4.8 and 39; 4.0 and 40; 3.2 and 42; 2.8 and 49; 1.2 and 57; 0.6 and 65 (LSD 0.05 for yield, 15 lb.).

Studies on the etiology and control of the radish pit disease. Cox, R. S., V. J. Carroll, and R. A. Benedict. A storage and transit disease called radish pit is a serious threat to the radish industry in Florida. Symptoms appear initially as water-soaked areas within 48 hours after harvest. These areas develop into discrete pitted lesions within 3–5 days. A typical temperature-response curve (cardinal temperatures of 15°, 30°, and 35°C for disease development) for microorganisms, constant association of bacteria with lesions, and control of the disease with antibiotics suggested a bacterial etiology. Following 5-minute dip treatments, radishes were held in perforated cellophane bags at 10°, 15°, 20°, 25°, 30°, and 35°C. After 5 days, percentage infections at the above temperatures, respectively, were as follows: check—0, 47, 65, 100, 100, 10; 10 ppm Terramycin (oxytetracycline)—0, 5, 8, 76, 90, 2; 20 ppm Terramycin—0, 1, 2, 21, 45, 5; 40 ppm Terramycin—0 at all 6 temperatures; 40 ppm streptomycin sulfate (technical grade)—0, 36, 69, 85, 100, 4. Bioassays (sensitivity 0.03 ppm) for Terramycin were run on unwashed samples of radishes by means of the standard plate method and *Bacillus cereus* var. *mycoides*. Five-minute treatments in Terramycin solutions of 0, 5, 10, 20, and 40 ppm gave the following levels, respectively: <0.03 (no zone), 0.050, 0.064, 0.164, and 0.420 ppm.

The effect of seeding methods on the severity of white tip of rice. Cralley, E. M. Experiments were conducted during 1954-56 on the effects of seeding methods on the severity of the foliar nematode disease of rice known as white tip (caused by *Aphelenchoides oryzae* Yokoo). The following seeding methods were tested: 1) rice was seeded in water; 2) rice was drilled and the plots flooded when the rice was 3–4 in. high; and 3) rice was drilled and the plots flooded at the time of rice emergence. In all years, white tip was much less severe when rice was seeded in water than when it was drilled. It would appear that water seeding of rice offers a simple and practical method for the control of white tip. Since the organism is seed borne and not soil borne, it would not be necessary to seed in water every year in order to maintain satisfactory control of the disease.

Control of the potato rot nematode in Wisconsin. Darling, H. M. Soil fumigation studies on the control of the potato rot nematode, *Ditylenchus destructor* Thorne, were initiated in 1954 after its discovery in late 1953. Of several chemicals tested, ethylene dibromide gave the most promising results. Split applications (plow sole) of this chemical at a total rate of 6 gal. an acre (4 gal. on the first and 2 gal. on the second) were made in the spring and fall. Control approaching eradication was obtained on 1 heavily infested 20-acre field treated at the 6-gallon rate in the fall.

Culturing the potato rot nematode. Darling, H. M., L. R. Faulkner, and P. Wallendal. Large pure populations of the potato rot nematode (*Ditylenchus destructor* Thorne) have been obtained in 2 ways. A modified White's nutrient agar medium was used to culture undifferentiated tissue from potato, carrot, clover, and tobacco; later, uncontaminated nematodes were introduced to the growing tissues. From 3 to 4 months were required for large numbers of nematodes to develop. Excised rootlets from clover and tomato also were grown on the same medium, but large populations of the nematode did not develop on them. By means of pure-culture techniques, it was also possible to develop large populations of nematodes (in 3–4 months) in cultures of each of 37 species of 15 genera of fungi. The fungi were grown on standard potato-dextrose agar (clarified) medium in petri dishes so that the nematode could be observed at any moment. Individual cultures that developed from single gravid females of this species have been kept in culture since 1954.

Comparative effectiveness of four classes of seed-treatment materials on peas, beans, and cucumbers. deZeeuw, Donald J., and Robert A. Davis. Four classes of seed-treatment compounds including 9 insecticides, 18 organic fungicides, 9 mercury fungicides, and 9 organic fungicide-insecticide combinations were tested on peas, beans, and cucumbers at East Lansing, Michigan. All treatments were applied as slurries. Peas and beans received 1 oz./100 lb. of a mercury material or insecticide or 2 oz. of an organic fungicide. Cucumber rates were double these. Seeds were stored approximately 1 month before they were planted in late May, 1956. Thirty-four of the materials used on beans, 35 of those used on peas, and 38 of those used on cucumbers gave final stands significantly superior to that of the control. Organic fungicide-insecticide materials gave the best control of seed and seedling parasites of peas and beans (average stand 53.9 and 39.8 per cent, respectively, above respective controls) followed by organic fungicides (47.4 and 33.4 per cent) and organic mercuries (44.1 and 28.7 per cent). Mercury compounds were best as a class on cucumber (average stand 34.3 per cent above control) followed by organic fungicide-insecticides (31.7 per cent) and organic fungicides (29.7 per cent). Insecticides gave no significant protection when used without fungicides, and several proved injurious.

A clone of Kenland red clover for cross-protection tests with isolates of yellow bean mosaic virus. Diachun, Stephen, and Lawrence Henson. Plants of a selected clone (OP71 I-8) of Kenland red clover develop discrete local necrotic spots on leaves rubbed with an isolate (accession number 204-1) of yellow bean mosaic virus; systemic lethal necrosis commonly follows. Plants of the same clone become systemically mottled when inoculated with any one of 3 other virus isolates (accession numbers 263, 266, and 427) that differ somewhat from each other and from virus 204-1. Such mottled plants fail to develop either local or systemic necrosis upon being inoculated with virus 204-1; i.e. plants of clone OP71 I-8 invaded by any one of the 3 viruses are protected against local and systemic infection by virus 204-1. Thus cross-protection tests on clone OP71 I-8 provide evidence of close relationship among these 4 viruses, which had been indicated by the facts that they have similar host ranges, induce similar symptoms, and produce similar intranuclear inclusion bodies in *Vicia faba*.

Forage diseases in Alaska and their relation to forage crop production. Dickson, J. G., C. E. Logsdon, and R. L. Taylor. A study of forage plants and diseases in Alaska was made during the summer of 1956. Both native and introduced grasses, legumes, and other forage herbs, and their diseases, were studied and collected from the Aleutian Islands northward to the Yukon Valley. Most diseases common on this group of plants in the states were found at 1 or more locations in Alaska, although their economic importance in the 2 areas differed somewhat. Brome mosaic and yellow dwarf viruses were prevalent in the Matanuska and Tenana Valleys. A yellow virus was severe and widely distributed on *Lupinus nootkatensis*. Apparently this is an indigenous virus-host-leafhopper association and frequently is isolated completely from cultivated plants. Two smut fungi new to Alaska were found: *Thecaphora deformans* was collected on *Oxytropis* spp. and *Urocystis agropyri* on *Elymus mollis*. *Uromyces* spp., *Erysiphe* spp., *Ascochyta* spp., and *Phoma* spp. were abundant on most legumes.

Puccinia glumarum was abundant and severe on *Agropyron* spp. in the Yukon Valley and represents a potential threat to cereals and grasses.

On the significance of proline and pipecolic acid accumulation in western-X diseased peach leaves. DIENER, T. O., AND M. L. WEAVER. Vacuum infiltration of L-lysine into detached peach leaves led, after incubation at room temperature, to an accumulation of α-amino adipic acid, both in healthy and western-X diseased leaves (as evidenced by paper chromatographic analysis). Neither lysine nor α-amino adipic acid infiltration into western-X diseased leaves had a significant effect on their pipecolic acid content. L-Proline, DL-pipecolic acid, or a combination of both acids was introduced into the trunks of 2-year-old healthy peach trees (varieties Hale and Rochester) by means of Mauget plant feeders. No effect of these treatments could be observed. When a crude synthetic preparation of DL-pipecolic acid was introduced into similar trees, however, symptoms resembling those of western-X disease began to appear after 3 days. These included reddening of the veins, upward-rolling of leaf margins, irregular necrotic areas on the leaves that lead to a shot-hole condition, and eventual defoliation. Paper chromatographic analysis of the symptom-producing preparation revealed the presence, besides that of pipecolic acid, of a ninhydrin-reacting substance whose chromatographic behavior strongly suggested its identity with baikiain.

Optimum plot size for fungicide testing on peach trees. DOBIE, NORMAN D., AND LYLE D. CALVIN. To determine the optimum number of trees per plot to use to test fungicides for the control of *Taphrina deformans* on Improved Elberta peach trees, an orchard block of 180 2-year-old trees was divided into 4 sub-blocks that were sprayed on January 31, 1954, with 2 lb. Captan 50-W (50 per cent captan), 6 lb. Copper A (calcium copper chloride; 45 per cent Cu) 3 lb. Fermate (76 per cent ferbam), or 1½ quarts Puratized Agricultural Spray (7.5 per cent tris (2-hydroxyethyl) (phenylmercuri) ammonium lactate) per 100 gal. of water. Fungicides were applied to individual trees by hand application with a power sprayer. For statistical analysis, the percentages of diseased leaves were transformed by the arc-sin transformation. The average percentage of diseased leaves on trees sprayed with PAS, ferbam, captan, and Copper A were 7, 26, 60, and 76, respectively. When a randomized block design with 3 fungicides was imposed on the uniformity blocks, 1, 2, and 4 trees per plot gave average relative efficiencies of 100, 69, and 55 per cent, respectively. With 4 fungicides, 1, 2, and 3 trees per plot gave relative efficiencies of 100, 105, and 118 per cent, respectively. The data show no advantage for multiple-tree plots over single-tree plots.

Infected roots as a source of stem canker of soybean. DUNLEAVY, JOHN. *Diaporthe phasiolorum* var. *caulivora* was isolated from roots of field-grown soybean plants prior to the formation of cankers on stems. Plants with fungus-infected roots matured a few days earlier than noninfected plants and on numerous occasions formed no cankers on stems, although the fungus could be isolated from tap roots and the lower portions of stems just before maturity. Seedlings grown in soil contaminated with the causal organism had infected roots. When such seedlings were grown to maturity, the fungus penetrated the vascular systems of the stems and in some cases formed cankers just prior to maturity. Soybean stems killed by the fungus were buried in field soil in the fall. When these stems were recovered in the spring, mature perithecia and viable ascospores had developed. The fungus grew well on steamed field-soil, but its lateral growth rate was almost doubled by adding 2 per cent pulverized soybean leaves to the soil. Vertical rate of fungus growth in living plants was much greater in stems than in roots and increased in stems after pod set.

Comparison of two techniques for evaluating pathogenicity of Helminthosporium cultures. EARHART, R. W. Two recently developed techniques in which the water-soluble toxins produced by pathogenic organisms are substituted for the active organism are being used to measure pathogenic activity. Tests were made to compare these techniques for measuring the activity of *Helminthosporium victoriae* and *H. sativum* on seedlings of Victorgrain 48-93 and Southland oats. All cultures were obtained from South Carolina oat fields during the December, 1955, disease survey. Species classification, which was based on field responses of the oats, is to be verified by laboratory studies. In these tests, a few single-spore cultures were highly pathogenic when tested by one method and weakly pathogenic by the other. The results of the 2 methods were sufficiently in accord, however, that a high positive correlation existed when the activities of 100 single spores of each species were compared. In view of the discrepancy exhibited by individual cultures, there appears to be a need for evaluating each culture by both methods before the toxin filtrate alone is used as a measure of pathogenic behavior.

The influence of soil and air temperature on Verticillium wilt of tomato. EDGINGTON, L. V., AND J. C. WALKER. Microsclerotial isolates (M type) of *Verticillium albo-atrum* Reinke & Berth. had higher optimal and maximal temperature than did nonmicrosclerotial isolates (NM type) in culture. Relative influence of soil and air temperature on disease severity was studied by growing tomato plants, inoculated when 4–5 in. high, in soil at 20°, 24°, and 28°C in each of 4 greenhouses maintained at 16°, 20°, 24°, and 28° and rating disease severity according to a wilt index at 16–19 days. With various combinations of 20° and 24° soil temperatures with 16°, 20° and 24° air temperatures, both isolate types incited severe wilt. With 28° air and 28° soil temperatures, only the M type incited wilt. With 28° soil temperatures, the NM type incited no wilt at any air temperature; with 28° air temperatures, moderate wilt developed at soil temperatures of 20° and 24°. Thus soil temperature was more influential than air temperature on disease development. The temperature within the plant stem, as measured by a thermocouple, was influenced predominantly by soil temperature during the day and by air temperature during the night. As light intensity increased up to 2000 foot-candles, water uptake increased and soil temperature became more effective in controlling internal stem temperature.

Host range, pathogenicity, and temperature-moisture relationships of Phoma trifolii and Phoma herbarum var. medicaginis. EDMUNDS, L. K., AND E. W. HANSON. In host-range and pathogenicity tests, *Phoma trifolii* E. M. Johnson & Valleau incited severe infection on *Medicago sativa, Melilotus alba, M. officinalis, Trifolium pratense, T. resupinatum,* and *T. subterraneum*; slight infection on *Astragalus cicer, Coronilla varia, Lotus corniculatus, Trifolium hybridum,* and *T. lappaceum*; and no infection on 9 other legumes. *Phoma herbarum* var. *medicaginis* West ex Rab. incited severe symptoms on *Astragalus cicer, Coronilla varia, Medicago sativa, Melilotus officinalis, Trifolium alexandrinum, T. hirtum, T. incarnatum, T. lappaceum, T. medium, T. michelianum, T. pratense,* and *T. resupinatum*; slight infection on *Hedysarum coronarium, Lotus corniculatus, Melilotus alba, Trifolium agrarium, T. fragiferum, T. glomeratum, T. hybridum, T. pannonicum, T. repens, T. striatum,* and *T. xerocephalum*; and no infection on 6 other legume species. Inoculum of each pathogen was a composite of 10 isolates and was applied to the foliage by atomization. Optimum temperature for development of *P. trifolii* was near 24°C, but very good infection occurred also at 16°, 20°, and 28°C. Optimum temperature for *P. herbarum* var. *mediraginis* was about 20°. Both patho

gens produced most infection when the plants were kept in a moist chamber for 4 days following inoculation.

Control of hard seed of alfalfa with high-frequency energy. EGLITIS, MAKSIS, AND FOLKE JOHNSON. Separate samples of alfalfa seed with different amounts of hard seed were held in either paper or wooden containers placed directly between 2 horizontal electrodes of a 5 KW high-frequency generator operated at 27 MC and with an output of 1A. By varying the duration of exposure and then testing the seed for germination, it was found that the optimum temperature for highest percentage germination was 56°C. This required an energy exposure of 25–30 seconds. The percentage increase in germination over the controls with 4 typical samples was 1) 60 to 96, 2) 62 to 91, 3) 56 to 86, and 4) 60 to 92. The germination of the treated seed in the different samples was 10–36 per cent greater than that of untreated seed, depending upon the amount of hard seed present. The hard seed content was reduced from 30 to 3 per cent. When treated, then stored for 1 year at room temperature, seed continued to have a higher germination and fewer hard seed than did untreated samples. There appears to be no difference in the rate or appearance of the growth of plants as a result of the treatments. The action of the energy was to increase the water-absorption capacity of the seed.

A comparative study of the black stem fungi on red clover and alfalfa. ELLINGBOE, A. H., AND M. F. KERNKAMP. Fifty-nine monoconidial isolates of *Phoma herbarum* var. *medicaginis* from alfalfa and 53 monoconidial isolates of *Phoma trifolii* from red clover were compared for cultural type, radial growth, conidial production, spore septation, and spore size on potato-dextrose agar. The 112 isolates were grouped into 7 rather distinct cultural groups, but there was no correlation between cultural types and host from which they were isolated. No differences between the 2 species were noted when 16 isolates, 8 from each host, were compared on several media in plate cultures or on red clover and alfalfa stems at temperatures from 5 to 35°C. All isolates were pathogenic on both alfalfa and red clover. No morphological differences were apparent between the fungi on 268 collections of infected alfalfa and red clover from 8 states. Ninety-five per cent of the collections on red clover and 96.5 per cent from alfalfa had only non-septate spores. Since the fungi cannot be distinguished, it is recommended that the older name, *Phoma herbarum* var. *medicaginis*, be considered as the valid name for both the alfalfa and red clover black stem organisms.

Sweetpotato mosaic. ELMER, O. H. The causal agent of sweetpotato mosaic, a disease causing mosaic leaf pattern and dwarfing in the variety Nancy Hall, was transmitted to sweetpotato by core and sprout grafting. Sap transmission from infected fleshy root tissue was successful to tobacco but not to sweetpotato. Transmission was not obtained with sap of infected sweetpotato leaves, stems, or fibrous roots. Symptoms following core grafting developed on sprouts from infected roots. Foliar symptoms on sweetpotato following infection through sprout grafting were not observed on inoculated plants during their lifetime, but fleshy roots produced by such plants bore sprouts that developed mosaic symptoms. Sweetpotato mosaic virus from sap of infected tobacco produced conspicuous mosaic patterns on tobacco, tomato, and Gomphrena. Mild mosaic symptoms developed on Vinca and Zinnia. Local lesions were produced on *Nicotiana glutinosa*, *N. rustica*, petunia, and eggplant. The virus was usually lethal to pepper seedlings. Concentration of virus is low in the fleshy root sap of infected sweetpotatoes but is high (dilution end point 10^{-6}) in the sap of infected tobacco. The virus in tobacco-leaf sap remained infective after being heated for 10 minutes at 85°C but not at 90°C. Longevity of the virus in extracted tobacco-leaf sap held at room temperature was at least 67 days.

Influence of temperature and light on vesicle formation by Puccinia graminis var. tritici on artificial substrates. EMGE, ROBERT G. Uredospores of *Puccinia graminis* var. *tritici* (Eriks. & E. Henn.) Guyot formed structures corresponding to substomatal vesicles on artificial substrates in the absence of any added chemicals and/or nutrients under appropriate conditions of light and temperature. One per cent water agar, acid-washed filter paper, cellophane dialysis membrane, and cellulose acetate millipore filters were used as substrates. Hydrated spores were dusted on these surfaces and germinated for 2 hours in the dark at 70–75°F. They were then exposed to various light and temperature conditions for 6 hours. Appressorium-like structures were observed after 2 hours, penetration pegs after 4 hours, and early stages of vesicles after 6 hours of exposure to light in the range of 2000–5000 foot-candles at temperatures of 80–85°F. The vesicles completed development and produced what appeared to be infection hyphae when these plates were subsequently placed in the dark at 85°F for 16 hours.

The effectiveness of various soil fumigants for control of the soybean cyst nematode. ENDO, B. Y., AND J. N. SASSER. The soybean cyst nematode, *Heterodera glycines*, was reported from North Carolina in 1954 but has not been reported as occurring elsewhere in the United States. Information on the efficacy of soil fumigants for control of this pest has been lacking. In 1956, the following fumigants at the indicated rates per acre were applied 4 weeks prior to seeding: D-D (1,3-dichloropropene; 1,2-dichloropropane) at 20, 40, and 60 gal./acre; Dowfume W-85 (1,2-dibromoethane) at 4½, 9, and 13½ gal./acre; methyl bromide (bromomethane) at 1, 2, and 3 lbs./100 sq. ft.; Nemagon (1,2-dibromo-3-chloropropane) at 3 and 5 gal./acre; Telone (1,3-dichloropropene) at 20 and 40 gal./acre. No viable larvae were recovered from plots 1 month after treatment with methyl bromide, D-D (40 or 60 gal./acre), or Telone (40 gal./acre). Later, viable nematodes were recovered from these plots; however, numbers recovered were much fewer than those recovered from check plots. For treatments other than W-85 (13½ gal./acre) and Telone (20 gal./acre), white cyst counts were significantly less than those of the controls. In general, there was an inverse correlation between high cyst counts and nitrogen nodule formation.

A method of inoculating oats with barley yellow-dwarf virus in the field. ENDO, R. M. A rapid and efficient technique for inoculating oat seedlings with yellow-dwarf virus in the field was used to evaluate 3600 entries in 1956. Each entry was planted in 4 adjacent hills, 1 ft. apart, with 15–30 seeds per hill. Hill planting minimized the possibility of individual plant escapes. Three weeks after planting, the first 2 hills in each row were infested with viruliferous apple grain aphids (average of 1 aphid per plant). The aphids had been reared in the greenhouse on barley plants infected with a moderately virulent strain of yellow-dwarf virus. The remaining 2 hills were not infested. Since there was an abundance of food, there was very little movement of aphids from the infested to the noninfested hills. The aphids were killed after a 3-day feeding period, and all hills were sprayed with malathion 6 times at weekly intervals. Symptoms appeared 9–18 days after infestation. An average of 80 per cent of the plants in the inoculated hills were infected. The effect of the disease could be measured at any time by comparing diseased plants with virus-free plants growing in the same row.

Effect of yellow dwarf (red leaf) on the yield of oats. ENDO, R. M. The effect of yellow dwarf on oats was measured by comparing the yields of diseased and healthy plants. Three oat varieties in the seedling and boot stages were infested with viruliferous apple grain aphids. Viru-

liferous aphids were reared in the greenhouse on barley plants infected with a moderately virulent strain of yellow dwarf virus and used for the inoculation of oat plants in field plots. This was done by pulling the infested plants and laying them end to end within the rows (2 8-ft. rows, 4 replications of each variety). All plants were then sprayed at 5- to 7-day intervals for 7 weeks. Infection in the noninoculated controls and in plants inoculated in the seedling and boot stages was 1.1, 93.9, and 15.3 per cent, respectively. Yield reductions for the 3 varieties inoculated in the seedling and boot stages, respectively, were: Fayette, 94.3 and 10.4 per cent; Clintland, 94.4 and 21.8 per cent; and Rodney, 75.8 and 15.0 per cent. Thus plants infected prior to floret initiation were damaged most severely. The main effect was a reduction in the number of florets.

Influence of temperature upon the development of oak wilt fungus mats and pads in red oak logs in Iowa. ENGELHARD, ARTHUR W. The effect of temperature on the growth and development of fungus mats, including pads, of *Endoconidiophora fagacearum* Bretz on red oak logs (*Quercus* spp.) was investigated. In April, 1954, 4 logs 8–12 ft. long from 2 wilted oaks 8 and 11 in. d.b.h. were stored at 69°F. During the following 6 weeks, mats developed on all logs. In early 1955, 8 wilted oaks averaging 11 in. d.b.h. were cut into 34 5-ft. logs. Seven trees were still too green to produce mats, but old mats were found above 10 ft. on the eighth tree. Alternate logs, starting with the butt logs, were left in the woods as controls. Of the rest, 4 were stored at 43°, 3 at 55°, 4 at 69°, and 6 at 90°F. The logs were peeled by June 25, and the average number of mats developed per sq. ft. on the stored logs and on the outdoor controls respectively was as follows: at 43°, 1.62 and 1.80; at 55°, 1.21 and 0.95; at 69°, 1.27 and 1.35; and at 90°, 0 and 0.64. Mats and cracks were observed on all logs except those stored at 90°. Temperatures of 43°, 55°, and 69° are apparently favorable and 90° unfavorable for the development of mats between the xylem and phloem of wilted red oak logs.

Dwarf-leaf, a symptom of oak wilt. ENGELHARD, ARTHUR W., AND W. H. BRAGONIER. Although symptoms of oak wilt, caused by *Endoconidiophora fagacearum* Bretz, have been described, the presence of dwarfed leaves on infected trees has not been mentioned as being frequently characteristic of the disease on northern red oaks (*Quercus rubra* L.) and northern pin oaks (*Q. ellipsoidalis* Hill). The trees can be located soon after bud-break occurs on healthy trees, as infected oaks show delayed bud development followed by retarded leaf development in the entire crown. Thirty trees displaying these spring "dwarf-leaf" symptoms in Pilot Knob State Park in northern Iowa were observed to have a number of characteristics in common: pale green to yellow-green foliage, dwarfed leaves more pronounced in the upper part of the crown than in the lower part, and dwarfed leaves that cup or curl, turn yellow to brown, and become dry. Growth of clusters of leaves on the bole and limbs did not occur. The size of the leaves varied from little or, rarely, no development in the very top of the crown to apparently full size in the bottom of the crown. On most of the infected trees observed, the leaves varied from approximately 2 in. in length in the top of the crown to about ¾ full-size in the bottom of the crown.

Fusarium and Verticillium wilt diseases of Cicer arietinum. ERWIN, DONALD C. A wilt disease of *Cicer arietinum* L. (commonly known as garbanzo bean, gram, or chickpea) occurs in California and is characterized by yellowing of foliage and necrosis of xylem tissue. A *Fusarium* sp. was proved to be the incitant. Identification of the causal fungus has not been completed. Plants from 3 selections introduced from Ethiopia and from 1 selection made in the field were resistant to the fungus. Neither alfalfa nor cowpea were susceptible. *Verticillium albo-atrum*, isolated from garbanzo, was also pathogenic to garbanzo and incited a necrosis of xylem tissue and a wilt of inoculated plants.

A root collapse of alfalfa associated with the interaction of high soil temperatures and water-saturated soil. ERWIN, DONALD C., AND BILL W. KENNEDY. In the Imperial and Palos Verdes valleys of California, complete loss of alfalfa stands often occurs from July to September following heavy irrigation and is commonly referred to as "scald." Either the roots of affected plants collapse, or the xylem becomes necrotic and brown; plant death follows in 8–10 days. Scald was reproduced in the greenhouse by immersing potted plants in a water bath held at 39°C for 24 hours. Later tests showed that saturating the soil of potted plants with water at 39° for much shorter periods of time would induce scald. Potted plants growing in nonsaturated soil and at a soil temperature of 39° were not adversely affected. This shows that damage is due to the associative effects of high soil moisture and high soil temperature and not to high soil temperature alone. Severity of scald was greater in nonsteamed than in steamed soil. Forced aeration of saturated soil at 39°C decreased the severity and incidence of scald but did not prevent it. In field and greenhouse tests, clipping alfalfa immediately prior to irrigation at high soil temperatures predisposed plants to scald.

Inhibition of Erwinia amylovora by bacteria isolated from fire blight cankers. FARABEE, GARY J., AND JOHN L. LOCKWOOD. *Erwinia amylovora* and other bacteria were isolated from fire blight cankers on Bartlett pear and several varieties of apple. The associated bacteria were nonpathogenic, and many isolates were inhibitory to *E. amylovora* in agar-streak tests. Filtrates from liquid cultures were inhibitory when assayed in a liquid medium. The pH of agar adjacent to colonies of antagonistic bacteria and of inhibitory filtrates was frequently below pH 4.4, the lower limit for growth of *E. amylovora*. Antagonistic bacteria did not inhibit *E. amylovora* on agar media buffered at pH 6.8. Filtrates from cultures buffered at pH 6.8 were noninhibitory when assayed in a liquid medium. Filtrates from unbuffered cultures assayed in a liquid medium buffered from pH 4.4–6.8 were also noninhibitory. These data suggest that associated bacteria inhibited *E. amylovora* in culture by lowering the pH of media below that favorable for growth. Of 9 bacteria that prevented growth of *E. amylovora* in culture, 7 inhibited fire blight development when introduced into twigs of Jonathan apple simultaneously with *E. amylovora* in media buffered at pH 6.8. Two other isolates, noninhibitory in culture, also inhibited symptom development.

A chemical test for ratoon stunting disease of sugarcane. FARRAR, LUTHER L. Several tests used for determining the presence of viruses in plant tissues were tried in an attempt to find a chemical, or a combination of chemicals, that would give a color reaction for determining the presence of ratoon stunting disease in sugarcane. These tests gave inconsistent results; however, 3 per cent hydrogen peroxide in combination with concentrated hydrochloric acid consistently gave a color reaction when applied to nodal area tissue in the region of maximum fibrovascular bundle density. The following technique gave best results. Longitudinal sections were cut from the periphery of mature basal nodes, covered with 3 per cent hydrogen peroxide for 10–15 seconds, and blotted off. A similar amount of concentrated hydrochloric acid then was applied. After 20–30 seconds, a blue-green color reaction can be observed, at the leaf scar level, in the parenchymatous tissue around fibrovascular bundles from healthy sugarcane. Diseased cane is distinguished by the absence of this reaction. A reaction has been noted in diseased stalks but is always limited to single or exceptional bundles. Apparently, these are bundles that do not contain the virus. This reaction was observed consistently in mature basal nodes of 12 varieties of sugarcane.

Role of the male in reproduction of the golden nematode. FASSULIOTIS, GEORGE. To determine whether reproduction of *Heterodera rostochiensis* can occur without males, 1 golden nematode larva was placed on a root of each of 28 tomato plants growing separately in sterilized soil in plastic observation boxes. Four weeks after inoculation, 13 roots had small galls at the locus of infection; 10 of these contained developing females. The other 3 galls were dissected, and a fourth-stage male cuticle was found in one. Development of the females to the saccate fifth-stage and cyst formation appeared to be normal, but no embryonated eggs were found in the cysts. This indicates that the definitive shape of the female is not dependent on fertilization and that the golden nematode is not capable of parthenogenesis. It is suggested that some of the empty cysts found in field populations may be the remains of unfertilized females.

Observations on the absence of an internal microflora of surface-sterilized Radopholus similis. FEDER, WILLIAM A., AND JULIUS FELDMESSER. Recent efforts to grow nematodes on tissue callus, to study nematode-fungal complexes, and to make other fundamental studies have required the use of biologically clean nematodes. *Radopholus similis* was cleaned by soaking groups of 25 nematodes for 5 minutes in mercuric chloride, 1/1,000, followed by 3 serial washings and centrifugations in sterile distilled water. The clean animals were fully infective when placed on citrus roots; they retained their motility for 3 weeks when placed on various types of sterilized agar media on which they were unable to feed. No bacteria or fungi grew from cleaned nematodes placed intact on various agar media or that were cut aseptically after being placed on the surface of the agar media. The agar media used were potato-dextrose, nutrient, potato-dextrose-peptone, and yeast-extract. The nematodes were kept on the media for 1 month. These nematodes disintegrated without concomitant bacterial or fungal growth. The individuals of *R. similis* were taken from root lesions from which a number of species of fungi and bacteria consistently had been isolated.

Survival of Radopholus similis in field soil subjected to drying and to elevated temperatures. FELDMESSER, JULIUS, AND WILLIAM A. FEDER. Citrus soil naturally infested with *Radopholus similis*, the burrowing nematode, was kept in flats in direct sunlight in 4 series of tests conducted from May through August, 1956. Temperatures were recorded at regular intervals, and samples were taken from the flats to determine moisture content. At intervals, soil was removed from flats, placed in pots, and planted with nematode-free citrus and corn. Survival was determined by the recovery of nematodes from the roots of these hosts. *R. similis* survived after 27 hours in 1 test in which soil moisture fell from 3.0 to 0.9 per cent and soil temperatures were over 100°F for 12 hours, with a high of 115° during that period. In another test, in which soil moisture declined from 2.0 to 0.5 per cent and soil temperatures were over 100° for 2 hours 45 minutes (with a maximum of 109°), *R. similis* survived after 45 hours.

X-ray induced mutations for pathogenicity in the F_1 of race 22 × race 1 of the flax rust fungus. FLOR, H. H. Approximately 100 plants of each of 24 flax varieties were inoculated with F_1 urediospores of race 22 × race 1 of *Melampsora lini* that had been exposed to X-ray dosages found to be 50 and 90 per cent lethal. The 4 varieties that were susceptible to the F_1 culture were heavily infected. Based on the maximum number of uredia that developed on 1 variety, each resistant variety screened about 200,000 viable spores for mutants. The 3 varieties for which the F_1 culture was homozygous for avirulence were free of rust. Likewise, 5 of the 17 varieties for which the F_1 culture was heterozygous for avirulence were not infected. The pathogenicity of 67 of the 154 mutants that were secured on the other 12 varieties has been determined; they had 6 different pathogenicity patterns. Each mutant differed from the F_1 culture in ability to attack a single variety or a single group of varieties. The varietal grouping was the same as that established by linkage of the genes for pathogenicity in hybridization studies. This would be expected following a single "hit" of a gene or a segment of a gene string. Five of the mutants differed in pathogenicity from races previously encountered.

The vegetative origin of a new race of the flax rust fungus. FLOR, H. H. Equal quantities of urediospores of 5 races of *Melampsora lini* were mixed and increased on a susceptible variety of flax. Each race was virulent on a different one of 5 rust-differentiating varieties and avirulent on the other 4. The host range of the race-mixture increase was identical with the combined host ranges of the component races. The pathogenicity of urediospores from each differential that was susceptible to the race mixture was determined. Bombay and Stewart perfectly screened out races 41 and 16, respectively, the 2 North American races in the mixture. Inoculum from Birio, Cass, and Ottawa 700B, respectively, had the pathogenicity of races 218, 123, and 108, the 3 hybrid races in the mixture, except that a few uredia developed belatedly on each of these 3 flaxes when any 2 were inoculated with urediospores from the third. Birio, Cass, and Polk were susceptible to single- and multiple-pustule increases of these isolated infections. This new race apparently originated as a new combination of 2 of the 6 nuclei in the 3 hybrid races following fusions of the dicaryotic hyphae in the mutually susceptible host.

A canker disease of coffee in Guatemala. FLORES, MARCO A., RAMIRO PAZOS, AND FRANCIS J. LEBEAU. *Nectria dodgei* (imperfect stage, Cylindrocarpon) was proved by inoculation to cause cankers of coffee trees in Guatemala. Inoculation with isolates from old cankers resulted in a low percentage of infection, whereas inoculation with isolates from young cankers resulted in infection in 60 per cent of the tests, and inoculation with perithecia from cankers resulted in infection in 100 per cent of the tests. Infection occurs only through wounds. In nature, this disease usually is found only on mature trees; however, young branches may become infected when inoculated artificially. When healthy trees in a severely infested area were wounded, 30 per cent of the trees became infected within 15 days and 83 per cent within 30 days through natural spread of the fungus. Wounds 6–12 in. above the ground had a higher incidence of infection than those 3–4 ft. above. The common varieties of *Coffea arabica* are highly susceptible to this disease, but certain varieties of *C. arabica* and *C. liberica* are resistant to natural infection.

The effect of fertilizers on stalk rot of corn in Pennsylvania. FOLEY, DEAN C., AND C. C. WERNHAM. In 1954, 2 inoculation treatments (a check and a mixture of *Gibberella zeae*, *Diplodia zeae*, and *Pythium* spp.), 5 fertilizer treatments (0-0-0, 200-0-0, 200-0-200, 0-0-200 and 200-200-200), and 3 corn hybrids (Funk G10, Oh. M15, and Pa. 602a) were randomized and replicated 4 times in a split-plot design. Stalk rot severity was measured by 3 methods: extent of rotting, stalk breakage, and premature dying. The amount of rotting was the most accurate and consistent measurement. Stalk breakage counts were highly variable because of the interrelationship between the degree of stalk rot induced by the pathogenic organisms and the variable strength of the stalks. A count of premature dying gave a measurement of only the pre-frost phase of stalk rot. A high N:K ratio (200:0) greatly increased the severity of internal rot, stalk breakage, and premature dying. A low N:K ratio (0:200) reduced the amount of internal rot and stalk breakage. When the nitrogen and potassium level was high, the addition of phosphorus had no effect on the development of internal rot and the amount of stalk breakage, but it increased the amount of premature

dying. When stalk rot development was extensive, high fertility increased the amount of stalk rot over that at lower fertility.

A vascular form of the Curvularia disease of gladiolus. FORSBERG, J. L. *Curvularia lunata* (Wakk.) Boed. has been associated with leaf spot, flower blight, petiole girdling, and corm lesions on gladiolus. The fungus has not been reported previously as being a vascular parasite. Pure cultures of *Curvularia* sp. were obtained in isolations made from browned vascular tissues of diseased Picardy corms. Stained sections of the vascular tissue showed the fungus in the vessels and also in surrounding necrotic cells. Inoculation tests indicated that the fungus can enter the corms through the roots. In cultural and morphological characters, the fungus appeared identical with Curvularia isolates obtained from external corm lesions and leaf infections.

The fungicidal effects of some halogenated dinitrobenzenes on Curvularia lunata and Fusarium oxysporum f. gladioli. FORSBERG, J. L. Meta-dinitrobenzene and 1-chloro, 1-fluoro, 1-bromo, 1-iodo, 1,3-difluoro, 1,3-dichloro, 1,3-dibromo, 1,3-diiodo, 1-fluoro-3-chloro, 1-fluoro-3-bromo, 1-fluoro-3-iodo, 1-chloro-3-bromo, and 1-bromo-3-iodo derivatives of 4,6-dinitrobenzene were tested as fungicides against *Curvularia lunata* (Wakk.) Boed. and *Fusarium oxysporum* f. *gladioli* (Massey) Say. & Hans. by the string technique. Curvularia was much more resistant to the chemicals than was Fusarium. Against both fungi, the fluorine-containing compounds were much more fungicidal than were the other compounds. The difluoro compound was more effective than was the monofluoro against Fusarium, but the reverse was true with Curvularia. Against Curvularia, the chloro compounds were only slightly effective, the bromo and iodo compounds were ineffective, the fluorochloro and fluoroiodo compounds were more effective than the monofluoro and difluoro compounds, and the fluorobromo compound was about equal to the monofluoro and difluoro compounds. Against Fusarium, the fluorochloro, fluorobromo, and fluoroiodo compounds were much more effective than were the monofluoro and difluoro compounds; the dibromo and dichloro compounds were much more effective than were the monobromo and morochloro compounds, respectively. The iodo compounds were relatively ineffective.

Prevalence and nature of boll blight of flax. FREDERIKSEN, R. A. Boll blight, one of the most common diseases of flax in Minnesota and surrounding area, varies greatly in prevalence and importance from one season to another and from 1 locality to another in the same season. In certain years, it is not uncommon to find a field with 20 per cent of the bolls blighted. The boll damage may range from injury to a single ovule to destruction of all the seed. Observations and tests in the greenhouse and field indicate that boll blight may be induced or aggravated by mechanical injuries, insect damage, and mineral deficiencies. Viruses such as those of aster-yellows and curly top frequently induce boll blight, and it is also commonly associated with wilt, rust, and pasmo diseases. Although many fungi were isolated from discolored bolls and diseased seeds, only a few induced blight unless the bolls were first injured by mechanical means. Septoria, Colletotrichum, Fusarium, and Alternaria alone and in combinations induced boll blight by attacking either the pedicels or the boll directly. Even though fungi, especially Alternaria, are frequently associated with shriveled and discolored seed, some specimens of damaged seed failed to yield fungi when plated out on nutrient media.

Fungicidal drenches for pink root control in shallots. FREEMAN, T. E., AND E. C. TIMS. Tests were begun in 1953 for chemical control of shallot pink root (caused by *Pyrenochaeta terrestris* (Hansen) Gorenz, J. C. Walker, & Larson) in the soil. Although little information was available, a basic screening of fungicides for their ability to control the fungus was begun. By means of Forsberg's string method, 44 fungicides were tested in the laboratory for their ability to kill the pink root fungus in culture. Seven fungicides killed the fungus at rates that would be practical to use on a field basis. All fungicides except maneb were organic mercury compounds. The fungicides were Agrox (6.7 per cent phenylmercuriurea), Ceresan M (7.7 per cent *N*-(ethylmercuri)-*p*-toulenesulfonanilide), maneb, Mergamma (1.93 per cent phenylmercuriurea; 42 per cent γ-1,2,3,4,5,6-hexachlorocyclohexane), Mersolite 8 (97.5 per cent phenylmercury acetate), Semesan (30 per cent 2-chloro-4-(hydroxymercuri) phenol) and Setrete (7 per cent phenylmercury acetate). In field tests in 1954 and 1955, 6 of the fungicides significantly reduced pink root when applied to the open furrow as a drench. Application rate was 11 lb. per acre on a 6-ft.-row basis and 17 lb. per acre on a 4-ft.-row basis. Semesan, Setrete, and Agrox, in that order, gave very good control with an accompanying increase in green weight.

Chromogenesis occurring in cultures of isolates of Botryosphaeria ribis. FULKERSON, J. F. Among a collection of 277 isolates of *Botryosphaeria ribis* from 17 different host species, 16 isolates induced the violet color characteristic of the chromogenic form of this fungus. Chromogenesis occurred when isolates were grown on alkaline starch media for 6–12 days under continuous exposure to fluorescent light at an intensity of 300 foot-candles. Exposure to sunlight destroyed the color within 60 minutes, even if the culture temperature was maintained at 20°C. This color was irreversibly destroyed by addition of dilute acid. Nine of the 16 chromogenic isolates produced a yellow color when grown on potato-dextrose agar. The development of this yellow color was independent of light. Of the "yellow-type" chromogenic isolates, 6 were from blueberry, 1 from apple, and 2 from other hosts. Some "yellow-type" isolates were not chromogenic on starch media. Of the 7 chromogenic isolates not of the "yellow-type," 4 were from redbud, 1 from blueberry, 1 from apple, and 1 from an unknown host. The 2 chromogenic isolates from apple were also atypical in other cultural characteristics; they differed from all other apple isolates of *B. ribis* used in this study.

Mechanical transmission of Prunus viruses to cherry. FULTON, ROBERT W. An objective of previously reported work on properties of Prunus viruses was to find factors favoring maximum infectivity, since mechanical inoculation of *Prunus* spp. would simplify virus identification. Inocula from different sources were found to vary greatly in infectivity. The best source for viruses A, E, and G was chlorotic tissue of cucumber cotyledons 4–7 days after inoculation. For virus B, the best source was systemically infected squash leaves. Young seedlings of certain *Prunus* spp. were susceptible to mechanical inoculation. In tests with all 4 viruses, *P. pennsylvanica* and *P. mahaleb* were more readily infected (33–29 per cent) than were *P. cerasus*, *P. virginiana*, or *P. serotina* (10–5 per cent). No infection resulted when *P. persica* or *P. tomentosa* were inoculated. Species varied in susceptibility to different viruses. Virus B infected mahaleb more readily (64 per cent) than did virus E (8 per cent), but it infected pin cherry less readily (16 per cent) than did virus E (28 per cent). After seedlings developed about 8 leaves, they were relatively insusceptible. Chlorotic and necrotic symptoms appeared on pin cherry in 7–10 days; on mahaleb, chlorotic symptoms appeared in 2–3 weeks. Viruses reisolated from infected seedlings were shown by differential-host reactions to be the same as those used for inoculation.

Differences in properties of mechanically transmitted Prunus viruses. FULTON, ROBERT W. Four sour cherry virus isolates (A, B, E, and G) differing in host ranges were compared. Infectivity assays of viruses A, E, and G

in cucumber-cotyledon extracts were made by inoculating guar or *Momordica balsamina* and counting the lesions. Assays of virus B in squash extracts were made on *Sesbania exaltata*. Rinsing of leaves after inoculation reduced infection markedly. Extracts prepared with 0.01 or 0.03 M phosphate buffer were much more infectious than those prepared with 0.1 M buffer. Viruses A, E, and G were most infectious at pH 8.0, virus B at pH 8.7. Dilutions of crude sap were much less infective than were extracts prepared by grinding tissue in buffer. Extracts diluted 1:25 were used for thermal-inactivation and aging trials. Inactivating temperatures, for 10-minute exposures, were as follows: virus A, 54°C; virus B, 44°; viruses E and G, 56°. At 24°, extracts of virus A became noninfective (for cucumber) in 9 hours; viruses B and E in 18 hours; virus G in 12 hours. Extracts of viruses A, E, and G lost more than ½ their infectivity in less than 1 hour. Virus B extracts lost about ½ their infectivity in 2 hours.

The sexual stage of Phytophthora infestans in Mexico. GALLEGLY, M. E., AND J. GALINDO. Following the discovery that oospores were produced abundantly when certain Mexican isolates of *P. infestans* were paired with isolates from the United States, oospore formation was studied in Mexico. Union between the antheridia of United States isolate 256 and the oogonia of Mexican isolate 43 was observed on water agar. When 91 Mexican isolates were paired on V-8 juice agar with each of these 2 isolates, 57 per cent mated with isolate 43, and 43 per cent mated with isolate 256. Eighteen isolates from the United States and Canada maintained in Mexico mated only with isolate 43. Both compatibility groups were found in isolates from Toluca, Chapingo, and Popocatepetl. Oospores, similar to those produced in pure culture, were found in infected Katahdin leaves collected at Toluca. It is believed that oospores play a part in the development of physiologic races and survival of *P. infestans* in Mexico.

"Enanismo," a virus disease of cereals in southern Colombia. GIBLER, JOHN W. A dwarfing caused by an unidentified virus occurs extensively on cereals in the department of Nariño and also in northern Ecuador. Symptoms vary from rosetting with no spikes produced to a slight stunting. There are no leaf or spike symptoms, but the grain is frequently shriveled and of low test-weight. The disease can be controlled by proper date of planting and the use of tolerant varieties. All the introduced barley varieties tested so far are highly susceptible, but native selections DC 7N, DC 2N, F.R. 1391, and F.R. 1714 are nearly immune. Their resistance can be readily transmitted, indicating a fairly simple inheritance. In wheat, Ciento Cienquenta, Thatcher, and many Colombian hybrids such as Frocor (McMurachy × Kentana-Yaqui) are tolerant. This tolerance tends to break down, however, during certain dates of planting that correspond to the highest incidence of leafhopper population.

Observations on scarlet oak mortality in eastern West Virginia. GILLESPIE, W. H., AND R. P. TRUE. During recent years, an extensive unexplained dying of oaks has occurred in the eastern part of West Virginia. This condition is similar to that reported from Pennsylvania, New York, and New Jersey and has caused appreciable losses of scarlet oak and losses of scattered red and black oaks. No fungi considered capable of inducing this condition have been isolated consistently. Cankers similar to those associated with drought have been observed upon oak and red maple trees in some of the sites. The boundaries of areas containing infected trees closely follow the tilted Devonian shales that give rise to the Ashby and Calvin soil types. Three droughts have occurred in the area during the past 5 years. Many single trees and dozens of areas that range in size up to a square mile have been observed within the affected area of approximately 400 square miles. Oak wilt surveys are ineffective where this condition occurs.

Variation in pathogenicity of Colletotrichum lagenarium. GOODE, M. J., AND N. N. WINSTEAD. In North Carolina during 1954 and 1955, outbreaks of anthracnose caused by *Colletotrichum lagenarium* occurred on watermelon varieties previously considered resistant to the disease. Single-spore isolates from resistant watermelons and various susceptible cucurbits were used to inoculate seedlings and fruits of several varieties and breeding lines of cucumber (*Cucumis sativus*), watermelon (*Citrullus vulgaris*), and squash (*Cucurbita moschata*, *C. pepo*, and *C. maxima*). The isolates were separated into 3 groups according to pathogenicity. The watermelon varieties Congo, Fairfax, and Charleston Gray were moderately resistant to isolates of group 1, very susceptible to group 2, and highly resistant to group 3. Plants of Butternut squash (*Cucurbita moschata*) were susceptible to isolates of groups 1 and 2 but highly resistant to those of group 3. All isolates caused severe disease on plants and fruits of the cucumber varieties Model and Palmetto and the watermelon varieties New Hampshire Midget and Garrison. On the basis of these results, it is evident that there are 3 or more physiologic races of *C. lagenarium*.

Germination of oospores of Phytophthora infestans. GOUGH, F. J., J. J. SMOOT, H. A. LAMEY, AND J. J. EICHENMULLER. Oospores, produced by pairing pure cultures of appropriate isolates of *P. infestans*, germinated by forming 1 or several germ tubes emerging through the antheridium or by rupturing the wall at other locations. Germ tubes usually produced terminal sporangia that were typical of the species with regard to morphology and methods of germination. Germination began in about 3 days under favorable conditions and continued for approximately 2 weeks. Maximum germination (10 per cent) occurred when oospores were placed in 0.08–0.4 per cent infusions prepared from dung of horse, cow, or sheep, or in leachates of soil from potted potato plants. Attempts to stimulate germination with many different organic and inorganic chemical compounds were unsuccessful. Some oospores from 1- to 6-month-old cultures germinated. Germination occurred at temperatures ranging from 12° to 25°C. A sporangial suspension obtained from a single-oospore culture infected susceptible potato plants under conditions favorable for infection; typical symptoms resulted.

A Stemphylium disease of Ladino white clover. GRAHAM, J. H. A previously unreported disease of Ladino white clover has been observed in central Pennsylvania for 3 years. Lesions consist of light brown necrotic areas up to 6 mm across, generally marginal. Conidia are light brown, have smooth or slightly rough walls, are usually pointed at the tip, and have 1–4 prominent constrictions. Conidiophores are swollen at the tips and may proliferate through the apex to produce additional conidia. In greenhouse inoculations, the fungus is pathogenic on many species of *Trifolium* and on alfalfa and sweetclover. Sclerotial bodies produced by the pathogen remain undifferentiated. Because of morphological and physiological differences, the Stemphylium is described as a new species and the name *Stemphylium trifolii* is proposed.

Fungicidal control of bitter rot. GRAVES, C. H., JR. The *in vitro* saturated-disk method for laboratory screening purposes was adapted for preliminary testing of fungicides for activity against spores of *Glomerella cingulata*. Two isolates of the fungus were used, one the incitant of the apple bitter rot disease, the other the incitant of camellia dieback. Many new and noncommercial materials have been tested. No difference between the 2 isolates was noted in reaction to the materials tested. Materials showing the most activity by means of laboratory tests and also certain materials presently being recommended for control

of bitter rot by either commercial concerns or government agencies were subsequently subjected to field tests. These tests were on Golden Delicious apples that exhibited annually an excessive natural incidence of bitter rot. Captan and thiram gave the best disease control; their use resulted in an excellent fruit finish in both cases. Dichlone, Tennessee Cu-Zn (basic copper and zinc sulfates; 26 per cent Cu and 12 per cent Zn), ferbam, Tennessee "26" (basic copper sulfate; 26 per cent Cu), Bordeaux (check), and glyodin gave varying degrees of intermediate to poor or no control, essentially in the order mentioned. Fungicidal activity as indicated by laboratory screening tests was in agreement with field results.

Cycloheximide analogues cause preinfection resistance to Puccinia graminis var. tritici in spring wheat. HACKER, ROBERT G., AND JOHN R. VAUGHN. Two new systemic antifungals, the semicarbazone of cycloheximide and the oxime of cycloheximide, applied as preinfection sprays in greenhouse and field tests, induced nearly complete resistance to *Puccinia graminis* var. *tritici* in the spring wheat variety Onas. Phytotoxic effects were negligible at the lowest effective concentrations used. Both compounds appear to be systemic in their mode of action and exert a long-term effect. In field trials, the semicarbazone analogue produced complete resistance at 200 ppm, with slight to moderate phytotoxicity. In plots receiving 100 ppm, traces of rust developed on isolated plants; there were no phytotoxic effects. Two applications were made—at the boot stage and 10 days later when the plants were in full flower. The time lapse between the first application and development of maximum infection in the check plots was 40 days. The chemotherapeutic effect of this material persisted for no less than 30 days. The oxime of cycloheximide was more effective than the semicarbazone analogue when applied as a preinfection spray to Onas seedlings in the greenhouse. This material gave almost complete protection at a concentration of 50 ppm and was only slightly toxic.

Host-range and inoculation studies on pea enation mosaic virus. HAGEDORN, D. J. Forty-four legumes, many untested previously, were studied in the greenhouse to determine their reaction to the pea enation mosaic virus. The rubbing method of inoculation was used. Susceptibility of 27 species was indicated by symptom expression. Twenty of the 27 were proved susceptible by recovery of the virus. Eleven new hosts for the virus were discovered: milk vetch (*Astragalus rubyi*), chick-pea (*Cicer arietinum*), flat pod pea vine (*Lathyrus cicera*), tangier pea (*L. tingitanus*), white lupine (*Lupinus albus*), blue lupine (*L. angustifolius*), cluster clover (*Trifolium glomeratum*), persian clover (*T. resupinatum*), subterranean clover (*T. subterraneum*), woolypod vetch (*Vicia dasycarpa*), and hungarian vetch (*V. pannonica*). Six other new hosts developed symptoms, but presence of the virus was not confirmed. Comparative studies on efficiency of the rubbing method of inoculation versus atomization at 15 and 25 lb. pressure were made with 14 leguminous species. The rubbing method was superior to atomization, and 25 lb. pressure was better than 15.

Water congestion in canning peas. HAGEDORN, D. J. A previously undescribed nonparasitic disease of canning peas, which is due to water congestion, occurs commonly in Wisconsin. Severity varies, depending upon local environal conditions. The outer edges of leaflets and stipules are affected primarily. Symptoms consist at first of a water-soaked, darkened appearance of diseased tissue, followed by a collapse and drying of such areas. As drying takes place, the dead tissue turns straw-colored. In severe cases, leaflets and stipules are malformed and much smaller than normal in size. Controlled greenhouse experiments indicated that the disease developed most rapidly and severely under conditions of high temperature, high soil moisture, and high relative humidity. Peas grown under greenhouse conditions in clay or muck soil developed more disease than did those grown in sandy or silt loam soil. Early, fast-growing pea varieties such as Alaska and Thomas Laxton were generally more susceptible than were late maturing varieties.

Genetic factors for pathogenicity in physiologic races of Ustilago avenae. HALISKY, P. M., AND C. S. HOLTON. Three races of *Ustilago avenae* (Pers.) Rostr. (A-5, A-6, A-7), characterized by well-defined differential host reactions, were selected for a study of genetic factors governing pathogenicity. The results show that a given spore from a known race may be either homozygous or heterozygous for pathogenicity. Thus, the progenies of homozygous parents were characterized by 4:0 ratios of strongly pathogenic to weakly pathogenic lines, whereas those from heterozygous parents were characterized by 4:0, 3:1, or 2:2 (strong to weak) pathogenicity ratios. These results may be explained by postulating a genetic system of complementary factors (A–B–) for pathogenicity. Differential host reactions among the 3 races on Monarch and Camas may be explained by specific genetic factors governing the pathogenicity of each race. These genetic constitutions were designated as "mmcc" for A-5, "MMcc" for A-6, and "MMCC" for A-7. A new race that originated in a cross of A5 $\times$ A7 was characterized by its pathogenicity on Camas but not on Monarch. This race was genetically designated as "mmCC," thus differentiating it from both its A-5 and A-7 parent races.

Host specificity in Pythium graminicolum. HAMPTON, RICHARD O. Isolates of *Pythium graminicolum* Subr. were obtained from the roots of corn, wheat, barley, rye, and Setaria plants growing in field soils. Each crop isolate was used to infest potted greenhouse soil that was planted separately to 3 varieties of the crop corresponding to isolate origin. Seedlings of 3 varieties of oats were inoculated with a corn isolate, since *P. graminicolum* was not isolated from the roots of oat plants grown in naturally infested soil. The infested soil was planted 8 successive times with the crop from which the isolate came, except for the oats. Each of the 18 isolates collected after the eighth planting was tested for specificity on its respective host. Analysis of 5 categories of data including root weights, top weights, total weights, root-top ratios, and plant-top indices indicated that isolates from corn, oats, and Setaria were more pathogenic, particularly on corn, than were isolates from barley, wheat, or rye. Fifty per cent of the comparisons among the over-all totals of crop isolates on crops, including all categories of data, indicated that there were tendencies toward host preferences among the isolates; however, these interactions were most often not significant statistically.

Further studies on symptoms of northern anthracnose and on the host range and physiologic specialization of Kabatiella caulivora. HANSON, E. W. Stem and petiole symptoms of northern anthracnose incited by *Kabatiella caulivora* (Kirchn.) Karak. are well known. The leaf symptoms, however, are not familiar to most workers. Petiolules are extremely vulnerable to attack; when infected, they turn dark brown. The attached leaflets frequently twist so as to expose their undersides. Symptoms on the leaflets vary considerably with the clone or strain of host. Commonly, the veins become dark; small to large, elongate lesions with dark margins and light-colored centers develop; or large areas of the leaves turn first olive gray and later light to dark brown as if they had been scorched. Any part of the leaf may be affected. In host-range studies, *Trifolium pratense*, *T. alexandrinum*, and *T. lappaceum* became severely infected. Moderate to light infection developed on *T. fragiferum*, *T. hybridum*, *T. incarnatum*, *T. medium*, *T. repens*, *T. resupinatum*, *T. striatum*, *T. subterraneum*, and *T. wormskjoldii*. No infec-

tion was obtained on 28 other species of legumes. The existence of races of *K. caulivora* differing in pathogenicity on 10 differential clones of red clover was demonstrated.

Inheritance of Cercospora resistance in pepper. HARE, W. W. Resistance to Cercospora leaf spot in 4 small-fruited strains of pepper was very high in the field, but there was light infection in greenhouse inoculations. One of them, 46101 from Para, Brazil, was crossed with Truheart pimiento and the F_1 backcrossed to Truheart and Early California Wonder. Resistance in F_1 plants inoculated in the greenhouse was definite and almost as high as in 46101. F_2 and backcross generations inoculated 3 times in the greenhouse gave inconclusive results. These plants, including resistant and susceptible parents, were then transplanted to a field plot. Plants were later scored for number, size, and distribution of spots and for defoliation. Resistance was almost complete in 46101, and susceptible parents were severely defoliated. Ranking of 65 F_2 plants by total scores gave 1 as low as 46101 and 2 as high as Truheart. The remainder were distributed in all intervening classes, with a slight peak about midway of the parents. Apparently, several genes were involved in inheritance of the resistance. A similar distribution of 69 plants of the F_1 backcross generation occurred when compared to the respective susceptible parent, except that no plant was in the same class with 46101.

Development of barley scab and varietal resistance. HASKETT, W. C. Eight isolates of *Gibberella zeae* varied in their ability to parasitize barley spikes. One isolate was highly pathogenic, 6 were moderately so, and 1 was weakly pathogenic. Greenhouse studies revealed that spring barley is susceptible from the boot stage to the mature-grain stage. The critical stage of development for infection was from flowering to the milk stage. A 72-hour incubation period produced a higher incidence of scab than did 48 or 60 hours. Higher scab readings were obtained at 24° than at 19° C. Infection of barley spikelets through dehisced anthers was commonly observed. Chevron C. I. 1111 and Peatland C.I. 5267 showed the least incidence of scab and head blight among varieties tested in 1951 and 1952. Hybrids that include Chevron in their parentage were intermediate in reaction. Several plant introductions appeared to be as resistant as Chevron or Peatland.

Chemical control of damping-off in alfalfa cuttings. HASKETT, W. C., E. D. HANSING, AND E. L. SORENSEN. To control damping-off, 300 ppm *N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide (as Captan 50-W), 3 ppm cyano (methylmercuri) guanidine (as Pano-Drench 4), 500 ppm disodium ethylenebis [dithiocarbamte] (as Dithane D-14), and 750 ppm sodium dimethyldithiocarbamate and sodium derivative of 2-mercaptobenzothiazole (as Vancide 51) were each applied in 1 liter of water per sq. ft. of sand bed 1 day before planting alfalfa cuttings. The most satisfactory control was obtained by Captan 50-W and by steam sterilization. Treatment with Captan 50-W resulted in healthy plants, no toxic effects, and a slight adverse effect on nodulation. Pano-Drench 4 was slightly less effective and did not affect nodulation. Vancide 51 and Dithane D-14 effectively controlled damping-off but induced chlorosis, suppressed normal root development, and prevented nodulation. Steam sterilization was effective in preventing damping-off, did not produce toxic effects, but destroyed nodule-forming bacteria.

Peach storage rot control by preharvest applications of certain fungicides. HAWTHORNE, P. L., AND N. L. HORN. Dixigem peach trees were treated with DHA-S (98 per cent sodium salt of dehydroacetic acid) as follows: 1) 1 application of 1 lb. per 100 gal. of water 10 days before harvest, 2) 1 application of 2 lb. per 100 gal. 10 days before harvest, 3) 2 applications of 2 lb. per 100 gal. 30 and 40 days before harvest, and 4) 2 applications of 4 lb. per 100 gal. 30 and 40 days before harvest. Peaches from the variously treated trees were bruised and nicked with a knife, then stored at 60°F for 20 days. Fruit from untreated trees, injured in a similar manner, were used as controls and stored with the sprayed fruit. Inocula of *Sclerotinia fructicola*, *Aspergillus* sp., and *Pencillium* sp. were present as contaminants in the storage room. The percentage rot in the above treatments was as follows: 1) 10, 2) 30, 3) 50, 4) 60, and the control, 90. The 1- and 2-lb. applications 10 days before harvest were the most effective treatments. Timing of applications appeared to be an important factor in control. Concentrations of 0.25 and 0.5 per cent orthophenylphenate used in similar tests on the Dixigem and Elberta varieties did not reduce rot as much as did DHA-S.

Effect of a strain of alfalfa mosaic virus on the yield of clonally propagated Atlantic alfalfa. HENSON, LAWRENCE, AND STEPHEN DIACHUN. In 1956, clones of 100 plants of Atlantic alfalfa were mechanically inoculated with strain 190 of alfalfa mosaic virus. The virus was isolated from an infected plant of Atlantic alfalfa on the Experiment Station farm at Lexington in 1952 and has been maintained in tobacco and alfalfa in a greenhouse without obvious evidence of change. The dry-matter yield from 2 harvests of the virus-infected plants grown in 3-in. pots in the greenhouse was 46 per cent of that from healthy plants of the same clones. Three healthy and 3 inoculated plants of each of 100 clones were transplanted, May 22-24, to the field in alternate rows 3½ ft. apart with plants spaced 2 ft. in the row. Of 300 plants inoculated, a total of 160 plants (1, 2, and 3 of 20, 19, and 34 clones, respectively) were infected. Dry-matter yield from 2 harvests of the infected plants was 15 per cent of that from healthy plants of the same clones.

Outbreak of Puccinia graminis in Denmark in 1951 and the reactions of some Danish cereal varieties to certain physiologic races. HERMANSEN, J. E. Wheat stem rust was epidemic in Denmark in 1951. Rust, first found on Bornholm Island in early August, spread westward 50–100 miles weekly. Severe rust at Bornholm reduced 1000-kernel weight of Weibull's Eroica wheat from 42 g to 17–25 g; widespread rust in Jutland affected yield in local areas. Primary inoculum may have been wind-borne urediospores from other European areas or aeciospores (2500 regrowth barberries were lightly infected). In 1894–1901, small grains endured 5 epidemics; after the "Barberry Law" of 1903, stem rust was sporadic except for local epidemics in 1937 and 1938. Danish cereals were tested in Minnesota to races of *Puccinia graminis* Pers. from the Cooperative Rust Laboratory. Seedlings of 8 wheats (Otofte 56, Hunsballe R, Pajbjerg Konge, Abed 841, Weibull's Eroica, Weibull's Banco, Nord Desprez, Heines VII) were susceptible to tritici races 11, 15, 15B, 29, 34, 38, 40, 48A, 56, and 147. Cappelle Desprez was susceptible to all but 147. Five barleys (Abed Maja, Carlsberg II, Pajbjerg Drost, Weibull's Herta, Weibull's Rika) were mesothetic to these races. Four oats (Pajbjerg Rex, Borris Opus, Abed Palu, Svalof Stål) were susceptible to avenae races 2, 3, 5, 6, 7, and 7A. Four ryes (Sejet Kerne, Borris Perle, Svalof Kongs, Petkus) were susceptible to 2 isolates of the rye stem rust fungus.

Factors affecting a root rot of soybeans incited by Phytophthora cactorum. HERR, LEONARD J. In recent years a destructive root rot of soybeans has occurred in Northwestern Ohio. The incitant has been identified as *Phytophthora cactorum* (Leb. & Cohn) Schroet. Killing is thought to be due to girdling by rotting and to the resulting disruption of water translocation. Pots of soil, which contained groups of plants differing in age by weekly intervals, were infested at the same time. Young plants (1- to 3-week-old age groups) were more susceptible than older plants; however, as the time after infestation of the soil increased, the differences in susceptibility among age groups became smaller. The rate at which plants were killed decreased progressively in older groups of plants.

Disease incidence decreased with decreasing concentrations of inoculum. The method of adding inoculum to the soil and the location of the inoculum with respect to the plant greatly influenced disease development. Pathogen-free filtrates of culture solutions were not toxic to soybeans.

Nutritional studies of an isolate of Phytophthora cactorum inciting a root rot of soybeans in Ohio. HERR, L. J. This fungus, like most species of *Phytophthora*, required thiamin for growth. The nitrogen requirements of the fungus differed depending on whether sucrose or cellulose was used as the carbon source. When sucrose was used, the best chemically defined sources of nitrogen were potassium nitrate and L-asparagine. There was no significant difference in growth of the fungus on sucrose when supplied with these 2 nitrogen sources. With purified cellulose as the carbon source, growth occurred only when organic nitrogen compounds were used as the nitrogen sources. Of 10 nitrogen-containing compounds (amino acids and amides), L-asparagine and L-aspartic acid supported the best growth of the fungus.

Some manifestations of black measles of grapevines. HEWITT, WM. B. The cause of black measles of grapevines in California is not known. Plots in Red Malaga, Thompson Seedless, and Emperor vineyards mapped for 6 consecutive years showed that this disease occurs sporadically in different vines and that symptoms may reappear in the same vines only at infrequent intervals. In the Red Malaga plot that contained 2016 vines, 198, 158, 133, 389, 216, and 262 vines developed measles in the respective seasons from 1951 through 1956. During the 6 years, a total of 718 vines showed measles; of these, 362 showed measles in only 1 season, 190 in any 2, 99 in 3, 49 in 4, and only 15 in 5. Only 3 vines showed symptoms all 6 seasons. Only 138 vines showed symptoms in any 2 consecutive seasons, 65 in any 3, 15 in any 4, and 6 in any 5. Similar sporadic occurrences were found in the other varieties. After the vines were pruned in dormancy, replicated plots were sprayed with sodium arsenite (2.5 lb. As_2O_3 per 100 gal.) and with the triethanolamine salt of 2-*sec*-butyl-4,6-dinitrophenol (as DN-289 at 3 and 6 quarts per 100 gal.). In Thompson Seedless and Red Malaga, only the sodium arsenite plots had significantly fewer vines with measles than did the nonsprayed plots, and there were no differences among the plots the second season after spraying.

Anatomical changes associated with wood pitting, a suspected virus disease of Virginia Crab apple. HILBORN, M. T., AND FAY HYLAND. To avoid winter injury, Virginia Crab is used as an interstock propagated on seedling roots and top-worked with fruiting varieties. A "quick decline" develops soon after bearing begins. The fruiting variety has weak growth and few fruiting spurs and the interstock has twisted limbs, abnormal trunk ridges, deep bark crevices, and severe wood-pitting. Pitting of the wood, apparent when the bark is peeled off, results from the phloem projecting into the xylem. Anatomical studies disclosed various abnormalities. Some cambial initials become multinucleate, and the nuclei become distorted. Some cambial derivatives become abnormal, resulting in disorientation of xylem elements and phloem rays, large parenchyma islands in the xylem, wide xylem rays, degeneration of sieve tubes, and absence of sieve areas and companion cells.

Growth in vitro of marigold and tobacco tissue with nucleic acids and related compounds. HILDEBRANDT, A. C., A. J. RIKER, AND ELIZABETH MUIR. Tobacco tissue of normal origin from the hybrid *Nicotiana glauca* × *N. langsdorffi* and marigold tissue of crown gall origin were grown in chemically defined media with the addition of nucleic acids, their components, or the antimetabolite, thiouracil. Growth was stimulated by both filtered and autoclaved ribose nucleic acid (RNA) at 400 and 4000 mg/l, whereas desoxyribose nucleic acid (DNA) had no effect at low levels and was inhibitory at 4000 mg/l. RNA was an excellent source of nitrogen for the tobacco tissue but not for marigold tissue. DNA was not a good source of nitrogen for either tissue. Neither RNA nor DNA was a source of carbon for tobacco tissue. Tobacco tissue was inhibited by 400 mg/l adenine, cytosine, xanthine, thymine, or uracil, whereas hypoxanthine, guanine, and ribose supported progressively more growth with increasing concentrations. Marigold cultures were inhibited by 400 mg/l of all the purines and pyrimidines; adenine and guanine were the most inhibitory. Some stimulation occurred with low concentrations of cytosine, guanine, uracil, and ribose. Thiouracil was inhibitory to tobacco cultures at 10 or more mg/l and marigold cultures at 100 mg/l. Amounts of RNA that inhibited or stimulated these cultures, respectively, appeared comparable to the amounts inside stimulated or inhibited tobacco leaves infected with tobacco mosaic virus.

Microbial host range of Dorylaimus ettersbergensis. HOLLIS, JOHN P. *Dorylaimus ettersbergensis* de Man 1885 feeds parasitically in water-agar cultures on globose cells of a blue-green alga (*Chroococcus* sp.), green algae (*Chlorella vulgaris* Beyerinck and *Tetraedron* sp.), a protozoan (*Drepanomonas* sp.), and a fungus (*Cephalothecium* sp.). These microorganisms were separated by suitable methods, and the nematode was cultured on the individual forms in replicate plates. The microbial hosts were rated for their effectiveness in promoting rate of increase and final level of nematode population in the cultures. The microbial hosts in order of decreasing effectiveness were as follows: *Chroococcus* sp., *Chlorella vulgaris*, *Drepanomonas* sp., and *Cephalothecium* sp. Populations of *D. ettersbergensis* increased, on the average, from 3 (inoculum level) to 2500 nematodes after 4 weeks in Petri plate cultures of *Chroococcus* sp.

Microbiological reduction of nematode populations in water-saturated soils. HOLLIS, JOHN P., AND TITUS JOHNSTON. Populations of *Tylenchorhynchus martini* Fielding 1956 and *Tylenchorhynchus acutus* Allen 1955 were related inversely to the amount of flooding and rainfall in rice and soybeans, respectively, in soil-fumigation tests conducted in Louisiana in 1955. Assays were made in the laboratory of the effects on *T. martini* and on total nematode populations of the following treatments: 1) nonsterilized moist soil, 2) nonsterilized water-saturated soil, 3) sterilized moist soil, and 4) sterilized water-saturated soil. The soils used were a rice-field soil containing indigenous populations of *T. martini* and other nematodes and a soil of the Red River Valley to which were added populations of *T. martini* and other nematodes partially disinfested of their surface microflora by chemical treatments. The field observations were confirmed by more pronounced reductions in nematode populations in treatment 2 as compared with those in treatment 1. The effect of microorganisms in water-saturated soils was demonstrated by consistently greater reductions in nematode populations in treatment 2 as compared with treatment 4.

True-breeding resistance in tomato to infection by tobacco-mosaic virus. HOLMES, FRANCIS O. Tomatoes that tend not to become infected when exposed to contaminative contacts with tobacco-mosaic virus have been shown previously to owe their resistance to the presence of a single dominant gene. Until recently, however, only heterozygous resistant-type and homozygous susceptible-type plants were available. Now a line that is homozygous for the gene that confers resistance has been isolated. This true-breeding resistant line is characterized by red fruits of size, texture, and flavor comparable to those of ordinary market-garden varieties of tomato. The resistant-type seedlings thus far grown display 1 striking peculiarity. They develop only short internodes between their first 4 to 8

true leaves. Subsequent growth is vigorous and apparently normal. Color of ripe fruit tends to be uniform and well developed because the infrequency of infection by tobacco-mosaic virus carries with it a corresponding freedom from the uneven and deficient coloration that is commonly associated with infection by that virus.

Verticillium wilt of dogwood. HOLMES, F. W. Cultures of *Verticillium albo-atrum* Reinke & Berth. were obtained on potato-dextrose agar on August 17, 1955, from all wood chips tested from twigs of a dying dogwood tree, *Cornus florida* L., in Lynn, Mass. This fungus seems not to have been reported previously as causing a disease of dogwood. Two American elms, 5 sugar maples, 1 well-established flowering dogwood, and 10 newly transplanted flowering dogwoods were inoculated with a suspension of this fungus on June 15, 1956, through 2 chisel wounds near the base of each tree trunk. Distilled water was injected similarly into other trees of each species. Still others were designated untreated controls. Of the trees inoculated with *V. albo-atrum*, wilt or die-back was shown by the elms on June 25, by the maples on August 2, and by the well-established dogwood on August 6. By September 14, slight symptoms were shown by 6 of the inoculated newly transplanted dogwoods; none were shown by the other 4. No symptoms were observed on any of the trees into which distilled water was injected or on any of the untreated trees. The re-isolation of *V. albo-atrum* in pure culture from all 3 tree species confirmed its pathogenicity to maple and elm and established its pathogenicity to dogwood.

The cyclic occurrence of dwarf bunt of winter wheat in the Pacific Northwest and its possible relationship to the depth of spores in the soil. HOLTON, C. S., AND J. P. MEINERS. A theoretical explanation, based on requirements for spore germination in relation to farming practices, is offered for the cyclic occurrence of dwarf bunt (caused by *Tilletia contraversa* Kühn) of winter wheat in the Pacific Northwest. Soil management, particularly as it relates to the utilization of wheat stubble in soil conservation, is the key factor in this explanation. Factors affecting spore germination also are involved. Spores of the dwarf bunt fungus germinate best when the proper combination of such factors as temperature, light, moisture, and aeration, prevails. Plowing under infested stubble and surface soil brings the spores into an environment unfavorable for their germination, primarily because of inadequate aeration and the absence of light. Here the spores remain dormant until the next plowing operation returns them to the surface, where optimum germination conditions prevail. Wheat crops grown while the spores remain deep in the soil escape severe infestation, whereas crops grown when the spores are on or near the surface usually become heavily infested. Hence, the nature of the cyclic occurrence of dwarf bunt in any given infested area appears to be related to the depth of spores in the soil as determined by the schedule of deep plowing.

Structure-activity relationships in captan derivatives. HORSFALL, JAMES G., AND SAUL RICH. Captan has 5 structural features that could be involved in its fungitoxicity; the $-CCl_3$ group, the sulfur bridge, the diketone, the *N*-heterocycle, and the mobile hydrogens on the carbon atoms *alpha* to the ketones. The importance of the last is negated by the activity of the phthalimide analogue, which lacks such hydrogens. We lack data on the heterocycle, but it could act as an antimetabolite for an essential purine base. The diketone group is probably important because it occurs in numerous fungitoxic compounds, such as cycloheximide, isovalerylindanedione, phthalimide, and thiazolidinedione. The diketone structure, in all cases so far noted, is more toxic to spores of *Stemphylium sarcinaeforme* than to spores of *Monilinia fructicola*, but the addition of an $-S-CCl_3$ group reverses the effect. This effect of the $-S-CCl_3$ group occurs even with non-diketone structures such as trichloromethylbenzenethiolsulfonate. This is probably due to the sulfur bridge, because S-bridged compounds in general are more toxic to Monilinia than to Stemphylium. The $-S-CCl_3$ group always enhances the activity of compounds to Monilinia, but it often fails to do so for Stemphylium. When it does do so, the effect is presumably due to the electronegative $-CCl_3$ group because an electronegative $-N{=}O$ group is equally as effective as the $-S-CCl_3$ group when attached to the nitrogen atom of phthalimide.

Comparative reactions of attached and detached leaves to Phytophthora infestans. HOYMAN, WM. G. Thirty potted potato selections 6–12 in. in height and detached leaves from them were simultaneously inoculated with zoospores from a culture of race 0. The inoculations were made in a plastic-covered chamber at 70° F and 100 per cent relative humidity. The reaction of each of the 30 selections was recorded as soon as symptoms appeared, and the final reading was made the eighth day following inoculation. Sporulation occurred on attached and detached leaves of 8 selections. Sporulation occurred on the attached leaves of 1 selection, whereas the reaction of the detached leaf from it consisted of large lesions. The symptoms on both types of leaves of 3 selections consisted of necrotic spotting. The attached leaves of 4 selections showed no symptoms, whereas the detached leaves had necrotic spotting. No reaction was evident on leaves of 14 selections.

Influence of air-temperature maxima on the survival of Phytophthora infestans in potato leaves. HOYMAN, WM. G., AND JACK R. WALLIN. During 1954 and 1955, *Phytophthora infestans* appeared in potato fields at Scottsbluff, Nebr., despite several successive days of temperature maxima between 97 and 107°F. An isolate was obtained from a tuber grown at these temperatures. Two subcultures (SB and 105) of this isolate were compared with isolate 1 from a North Dakota tuber, with isolate 104 from Hollandale, Minn., and with monozoospore subculture 35 from 1. In 5 trials where the inoculated Red Pontiac plants were subjected to gradual temperature increases to maxima to 83°, 95°, 105°, 108°, and 114°F for ½–1 hour 12 hours after inoculation, all cultures produced conidia after exposure of the inoculated plants to 105° or below. In another trial, only culture 1 produced conidia after exposure of plants to 106° 15 hours after inoculation. Only cultures 1 and SB produced conidia when the plants were exposed to 106° 16½ hours after inoculation. All cultures produced conidia when the plants were exposed to 102° and 106° 19 and 23 hours, respectively, after inoculation. Only culture 1 produced conidia when the plants were exposed to 110°F 23 hours after inoculation. In all instances where conidia were not produced, the presence of necrotic spots on the leaves was evidence that infection had taken place.

Production of a cellulolytic enzyme by Sclerotium rolfsii. HUSAIN, AKHTAR. In a study of the role of enzymes in pathogenesis by *Sclerotium rolfsii*, crude culture filtrates were assayed for presence of a cellulolytic enzyme, C_x. Filtrates were prepared from cultures grown in a modified Richard's solution with carboxymethylcellulose (CMC) or glucose as sources of carbon. Cellulase (C_x) activity was determined by viscosity measurements and by the cup-plate method. A 1 per cent solution of CMC was used as substrate. With CMC as source of carbon, fungal growth rate was slower than with glucose as carbon source, but enzyme activity was 20 times greater. To investigate production of the enzyme *in vivo*, half-ripe tomato fruits were inoculated with a pathogenic isolate of the fungus. Three days after inoculation, when inoculated fruits were decayed, extracts of both infected and healthy fruits were assayed for presence of cellulase. Decayed fruits contained a significant amount of the cellylolytic enzyme, but none was detected in healthy fruit. The production of a cellulolytic enzyme by *S. rolfsii* in plant tissue as well as in culture indicates

that cellulolytic as well as pectic enzymes are involved in pathogenesis by this fungus.

Host-parasite relations of northern corn leaf blight. JENNINGS, PETER R., AND ARNOLD J. ULLSTRUP. Penetration of leaves of susceptible inbreds by *Helminthosporium turcicum* was usually (80–90 per cent) direct with appressorial formation. Infection hyphae, which caused limited parenchyma disruptions resulting in flecking reactions, contacted and entered xylem vessels and tracheids of vascular bundles. Subsequent longitudinal progress was confined to xylem, where hyphae branched and grew profusely. Lateral movement was through transverse bundles. No disease symptoms were apparent while mycelia progressively filled xylem conducting elements. Infected tissue wilted rapidly and then formed necrotic lesions after sufficient xylem plugging occurred. Hyphae moved into the moribund parenchyma of interveinal spaces only after lesions developed. Microscopic observations and staining with ruthenium red suggested that mycelia and not pectic materials caused vascular plugging and impeded water flow. Penetration and initial infection stages of resistant material were similar to early susceptible reactions. Infection hyphae invaded xylem, but subsequent development in resistant inbreds was markedly inhibited; mycelial branching and growth were so retarded that fungus plugging was insufficient to cause typical wilting, necrosis, or lesion formation.

Peppermint decline caused by Longidorus sylphus can be controlled by soil fumigation. JENSEN, HAROLD J., AND CHESTER E. HORNER. To control *Longidorus sylphus* on peppermint in Oregon, nematocides and fungicides were injected into or applied to the surface and rototilled into the soil before planting. Growth of transplanted cuttings was used to estimate the amount of control. In 1955, plants on some plots made approximately 16 times more growth than did the controls. The average weight (lb.) of hay from the 3 replications of each treatment was as follows: Vapam (sodium methyldithiocarbamate) injected (268.9 gal./acre), 4.57; Vapam applied to surface (268.9 gal./acre), 9.57; D-D (1,3-dichloropropene; 1,2-dichloropropane) injected (50 gal./acre), 13.43; EDB (1,2-dibromoethane) injected (7 gal./acre), 12.87; Nemagon (1,2-dibromo-3-chloropropane) injected (3 gal./acre), 13.33; formalin applied to surface (30 gal./acre), 2.47; and check, 1.12. In 1956 the differences in growth were not as great as in 1955 although they were statistically significant. The results were as follows: Nemagon granules (equivalent to 1 gal./acre), 12.07; Nemagon granules (equivalent to 2 gal./acre), 12.07; Nemagon injected (1 gal./acre), 8.97; Nemagon injected (2 gal./acre), 8.03; DCB-60 (60 per cent mixture of dichlorobutenes) injected (32 gal./acre), 8.17; and check, 4.7.

Inoculation of seedlings of Pinus elliottii var. elliottii with Cronartium fusiforme. JEWELL, F. F. In the development of methods of progeny and clonal testing for a disease-resistance program, 30-day-old slash seedlings were successfully inoculated with *C. fusiforme* in 4×4-ft. nursery plots covered with either single or double canvas frame tents. The basal ends of small oak branches were inserted in the beds so that the attached telia-bearing leaves formed a canopy over the plants. High humidity was maintained by spraying water intermittently over the plants during the first 8 hours and constantly on the single tent cover and between the double tent covers. Two plots of 450 plants each were treated under each tent for 72 hours; 2 untreated beds served as checks. Six weeks later, 69–98 per cent of the inoculated plants had red needle spots. Infection was verified microscopically. After 5 months, typical fusiform swellings were present on the stems of 60–83 per cent of the inoculated plants and on 2 per cent of the checks. Of several methods of inoculating potted 1-year-old plants, best results were from 1) wrapping the new growth in telia-bearing oak leaves covered by wet cotton and incubating for 48–72 hours in a lath house or a moist chamber (70 per cent infection) and 2) a similar treatment without the cotton and with incubation in a moist chamber for 48 hours (50 per cent infection).

A method for determining the degree of infestation by pea root-rot organisms in soil. JOHNSON, H. G. Infestation by pea root-rot organisms was determined by growing peas in samples of field soils in pots in the greenhouse and by grading the roots according to an arbitrary scale. A comparison of greenhouse root-rot readings and field yields showed that soil with an index of 10–30 (a low infestation) was safe for planting, that soil with one of 30–40 (a moderate infestation) should be avoided if possible, and that soil with one of 40–100 (a severe infestation) was hazardous for planting. The soil samples were made up of subsamples that represented the average topography of the fields, except that small depressions were avoided since they frequently were more severely infested than higher ground. Severe infestations reduced yields of a late variety more than it did yields of an early variety. The root-rot index is useful as an estimate of the hazard of planting fields to peas but cannot be used for prediction of yields because of variability of environmental conditions.

Effect of seed and soil treatments on alfalfa hay yields. JOHNSON, HOWARD W. Alfalfa seed treatment has been reported to improve stands, but there is little published data—none from the southern states—on its effect on hay yields. To obtain such data, seed of 10 alfalfa varieties treated with Arasan (50 per cent bis(dimethylthiocarbamoyl)disulfide) and with Spergon (96 per cent tetrachloro-*p*-benzoquinone) were planted at Stoneville, Mississippi, in October 1952 in comparison with nontreated seed. The dosage was 8 oz./100 lb. seed. A fairly uniform stand was obtained. Yields were determined for 3 hay cuttings per year over a 3-year period starting in 1954. Average yields of moisture-free hay per year in tons/acre were as follows: nontreated, 3.62; Spergon-treated, 3.67; and Arasan-treated, 3.68. In a companion test established the same fall, Arasan, Phygon (50 per cent 2,3-dichloro-1,4-naphthoquinone), and Ceresan M (7.7 per cent ethylmercuri)-*p*-tolunesulfonanilide) were incorporated in the soil before planting Oklahoma Common alfalfa. Each was applied at 4 and 8 lb./acre. For the 3-year period, the average yields of moisture-free hay per year in tons/acre were as follows: Ceresan-M-treated, 3.85; Arasan-treated 4.01; Phygon-treated, 4.11; and nontreated, 4.52. Neither seed nor soil treatment with fungicides proved beneficial in alfalfa culture at this location.

Association of the reactions to the crown rust fungus and to Helminthosporium victoriae in oat selections. JOHNSTON, PEGGY, R. R. ROMANKO, AND H. E. WHEELER. Treatment of more than 150 bushels of oats from varieties susceptible to *H. victoriae* with a toxin produced by this fungus has yielded a large number of resistant selections. Among varieties, the frequency of resistant forms varied widely and appeared to depend chiefly on the age of the variety. The lowest number of resistant selections, 0.5/bushel, was obtained from the recently released Park; the highest, 100/bushel, was obtained from the older variety Arlington, whereas the rate with both Victorgrain 48-93 and Fullgrain (1947 resel) was 3.4/bushel. Selections resistant to *H. victoriae*, from all 4 varieties, gave a complete range of reaction to race 202 of the crown rust fungus; most were susceptible, and only about 1 per cent possessed resistance equal to or greater than that of the parental varieties. Although these results confirm earlier reports of an association between the reaction to the crown rust pathogen and that to *H. victoriae* in oats, they indicate a more complex type of inheritance than simple linked factors or pleiotropic effects of a single gene, the 2 mechanisms previously postulated. The selections now available should be

useful not only as the basis for disease resistant varieties but also for genetic studies of the inheritance of resistance to these 2 pathogens.

Susceptibility of a number of sweetpotato varieties and selections to infection by Monilochaetes infuscans. KANTZES, JAMES G. Thirteen isolates of the scurf fungus were obtained from sweetpotatoes grown in California, Missouri, Oklahoma, Louisiana, and Maryland. There were differences among the isolates in rate of growth and sporulation and the frequency with which certain of them produced nonpigmented mutants. A number of sweetpotato varieties and selections were inoculated with each of the isolates. A laboratory inoculation technique was developed in which 6.35-mm filter paper discs were saturated with a standardized suspension of spores and mycelial fragments and placed on the surface of storage roots. Following incubation, zones of infection were measured and compared. The same isolates were used to inoculate plants of 20 varieties of sweetpotatoes grown in soil in the greenhouse; results were similar to those of the laboratory studies. None of the varieties and selections were immune from infection by any of the isolates; however, there were differences in the severity of infection on certain of the sweetpotato varieties and selections.

Root and stem rot of soybeans caused by a species of Phytophthora. KAUFMANN, M. J., AND J. W. GERDEMANN. Phytophthora root and stem rot occurs on soybean plants of all ages. It is characterized by a light brown canker that advances up the stem and by wilting of infected plants. A *Phytophthora* sp. has been isolated consistently from the margins of these cankers. In greenhouse tests, the isolates proved highly pathogenic to soybeans. When the fungus was grown on hemp seed in water, oogonia with paragynous antheridia formed in abundance. Sporangia are oval and nonpapillate. The fungus appears to be closely related to *P. megasperma.* In greenhouse tests, *P. megasperma, P. cactorum,* and *P. cryptogea* were not pathogenic on soybeans. Reactions of soybean varieties to this *Phytophthora* sp. may be determined rapidly in the greenhouse by inserting small amounts of mycelium into stems of young plants and covering the wound with petroleum jelly. All the plants of the susceptible varieties Hawkeye and Harosoy were killed by this method of inoculation, whereas all plants of the resistant varieties Illini and Monroe remained healthy. Results of studies on artificially inoculated F_2 populations indicate that resistance is controlled by a single dominant gene. The fungus grew equally well on extracts from plants of resistant and susceptible varieties.

Multiple spotting apparatus for paper chromatography. KENAGA, CLARE B. In paper chromatography, spot applications are often slow, tedious, and inaccurate when large volumes are employed. This reduces accuracy in quantitative determinations. A multiple automatic spotting apparatus, which allows the simultaneous application of 10 spots to various arrangements of filter papers held vertically on a separate adjustable drying rack, was developed. Up to 1 ml of material may be applied per spot from matched tuberculin syringes fitted with needles filed flush with the shank. An electric motor rotates a threaded screw that carries a cross-bar that pushes all of the syringe plungers simultaneously. The blunt needles of the syringes are lined up to the papers. The spots are dried with a hot-air drier. By means of a percentage timer, the multiple spotter can be adjusted over a wide range of delivery rates. When connected to an electric interval-timer clock, the apparatus can be set to deliver a prescribed amount in a predetermined time. When large volumes are used, replications are made with ease, accuracy, and saving of time.

Studies on the effects of several salts of 1-hydroxy-2(1H)-pyridinethione on several economic plants. KENAGA, CLARE B., AND RICHARD L. KIESLING. The sodium, copper, manganese, and zinc salts of 1-hydroxy-2(1H)-pyridinethione were screened for control of foliage diseases. These compounds when applied as sprays at 200 ppm controlled *Phoma lingam, Colletotrichum lindemuthianum,* and *Puccinia sorghi* in greenhouse trials; however, repeated application of the sodium salt as foliar sprays and as root drenches caused chlorosis and stunting. Bioassays showed no activity in aerial parts of plants grown in sand treated with the sodium salt. Ultraviolet spectra of guttation water collected from cucumber and corn seedlings grown in sand treated with the sodium salt revealed no upward translocation of the active compound. Differences in the spectra of the guttation water from treated and untreated cucumber plants were found. Plant sap from coleoptiles and leaves of radish inactivated the sodium salt in concentrations up to 100 ppm. Expressed plant juice from green cucumber and tomato leaves inactivated the compound at 50 and 100 ppm, respectively.

The effect of culture temperature on the sex-associated pigmentation phenomenon in monosporidial lines of Tilletia caries. KENDRICK, EDGAR L. Two pairs of pigmenting and nonpigmenting lines from each of 5 spores representing 2 races of *Tilletia caries* (DC.) Tul. were incubated at 10°, 15°, 20°, and 25°C. Cultures were incubated continuously at each temperature and also shifted from one temperature to another after a given period. Pigmenting lines produced pigment at all temperatures, rate and intensity of pigmentation being least at 10° and greatest at 25°; growth, however, was slowest at 25°. Some of the nonpigmenting lines were stable at all 4 temperatures, but others had a tendency to produce pigment in certain combinations of temperature. The best combination of temperatures for the expression of the differential pigmentation characteristic was 15° for 10 days followed by incubation at 20 or 25°.

A possible new source of high resistance to wheat smut. KENDRICK, EDGAR L., R. J. METZGER, AND C. R. ROHDE. The development of wheat varieties resistant to bunt (caused by *Tilletia* spp.) in the Pacific Northwest is primarily dependent on the utilization of the 3 major resistance sources known as the Martin, Turkey, and Ridit resistance types. Each of these provides protection against certain of the known 27 races while being susceptible to the other races. A combination of Turkey and Martin or of Turkey and Ridit resistance types provides protection against all of these races. Nevertheless, the dynamic nature of the wheat smut organism and its capacity to develop new pathogenic types make it imperative to search for new kinds and sources of resistance. In the screening of wheat varieties collected from all parts of the world against known races of *Tilletia* spp., several varieties have shown high and possibly new types of resistance. One of these varieties (P.I. 178383) is completely resistant to all 27 races. So far as is known, this variety is endemic to Turkey and probably is not a product of a breeding program for smut resistance. Such comparably high resistance has not heretofore been found in any variety except those possessing a combination of known resistance types. Therefore this may be a new kind and source of high resistance to bunt.

Control of Rhizoctonia stem canker of lima bean. KENDRICK, J. B., JR., A. O. PAULUS, AND J. DAVIDSON. Stem canker of lima bean, incited by *Rhizoctonia solani,* has been controlled in the field by seed furrow spray and dust applications of a mixture of pentachloronitrobenzene (PCNB) and *N*-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide (captan). Sprays and dusts containing equal parts of the 2 active ingredients were delivered to the seed furrow during the seeding operation at a rate of 80 mg per linear foot of row. The average concentration in the soil

was approximately 15 ppm by weight for each active ingredient. Sprays allowed better dosage control and are therefore to be preferred. Approximately 15 gal. of water, containing 1.5 lb. each of the 2 active materials, was used per acre with 30-in. row spacing. Spraying equipment consisted of a pump activated by the tractor power-takeoff, reservoir tank, manifold, flexible distributing system, and 2 Tee-jet nozzles per row. Sprays were directed behind the shoe into the moving soil covering the furrow. Treated plots, 4 weeks from seeding and treating, had an average reduction of 71.5 per cent in number of infected plants, an 82.4 per cent reduction in infection severity, and almost complete control of postemergence damping-off. There was no evidence of phytotoxicity in treated plots.

Laboratory evaluation of chemicals as potential soil fungicides. KENDRICK, J. B., JR., AND G. A. ZENTMYER. In laboratory tests designed to evaluate chemicals as soil fungicides, materials are first tested at 10, 100, and 1000 ppm in glucose-potato agar against 13 soil-borne pathogens representing the fungus genera of *Armillaria, Fusarium, Phytophthora, Pythium, Rhizoctonia, Sclerotinia, Sclerotium, Streptomyces,* and *Verticillium.* Compounds showing promise in agar tests are then assayed in vials of sterilized soil as mixes and drenches against each organism at the same 3 rates. Phytotoxicity is evaluated by germinating cucumber seed in similarly treated soil. All data are kept on marginal punch cards. Of approximately 800 compounds tested in the past 2 years, very few that showed activity in agar tests were also effective in soil. Nitrosomethyl carbamate, nitrile, and thiocyanate derivatives showed promise as soil fungicides in these tests. Pentachloronitrobenzene (PCNB) was specifically effective at 10 ppm as a fungistat against Rhizoctonia, Sclerotinia, and Sclerotium; sodium *N*-methyldithiocarbamate (Vapam) was generally effective at 10 ppm as a fungicide. Captan, thiram, chloranil, dichlone, and metallic salts of dithiocarbamates were not highly active as soil fungicides.

Translocation of peach rosette virus. KENKNIGHT, GLENN. Peach rosette virus was inoculated into 2-year-old peach trees in April; the virus moved more rapidly toward the roots than upward and did not pass a point where bark rings were removed. Of 10 trees severed 30 cm below the inoculum after 1 week, none rosetted; of 10 cut after 3 weeks, 7 rosetted. Twenty pairs of trees were united by approach grafts, and 1 of each pair was inoculated 15 cm below the union. The inoculated trees were bark-ringed or cut above the inoculation point but just below the union. Where the trees were severed, rosetting of the test tree demonstrated passage of the virus in 0 of 2 after 2 weeks; in 1 of 5 after 6 weeks; and in 3 of 3 after 16 weeks. There was no evidence of passage of the virus to the 10 ringed trees. In a series of 18 trees united by approach grafts to form chains, furthest advance of symptoms in 2 months after inoculation was 235 cm. In chains severed after 2 months, symptoms developed in trees separated from inoculum by 58, 114, 133, 140, 176, and 200 cm, but not in other trees separated from inoculum by 55, 80, 90, 130, 132, 135, 144, 149, 165, 177, 195, 236, 244, 268, 280, and 288 cm. In 3 chains separated after 7 months, the virus progressed approximately 60 cm but not 120; 240 cm but not 360; and 480 cm but not 600.

Translocation of phony peach virus. KENKNIGHT, GLENN. It was demonstrated experimentally that phony peach virus in peach stems traveled toward roots more slowly than upward. Downward movement was measured by approach grafting a branch of a peach test tree to a branch of a naturally infected peach or plum tree. After various time intervals, the grafted branch of a number of test trees was cut 15 cm below the point of union. For each time increment, the number of test trees that developed symptoms of phony peach was as follows: 2 weeks, 0 of 2; 3 weeks, 0 of 2; 4 weeks, 0 of 9; 6 weeks, 1 of 19; 12 weeks, 3 of 9; 52 weeks, 3 of 4; and 91 weeks, 3 of 3. In 11 other peach trees approach-grafted to naturally infected or artificially inoculated peach or plum trees, a 15-cm upward movement was demonstrated in 0 of 1 at 3 weeks; in 4 of 7 at 4 weeks; in 2 of 2 at 6 weeks; and in 1 of 1 at 8 weeks. The virus did not move up or down a stem past a point where bark rings were removed in any of 7 cases. All trees were grown under screen to preclude natural spread of the virus to test trees.

Reaction of forage legumes and other plants to Curvularia trifolii. KILPATRICK, R. A. Greenhouse inoculations were made with *Curvularia trifolii* on plants of *Trifolium repens* var. Ladino varying in age from 2 to 4 months. All were susceptible. Resistance appears possible in certain species. Seedlings of different species were inoculated with a conidial suspension, placed in a moist chamber for 72 hours, then removed to a greenhouse bench. Readings were made 7 days later. All tests were replicated and repeated. Twenty-eight species of *Trifolium* (*T. agrarium, T. alexandrinum, T. alpestre, T. amabile, T. ambiguum, T. angustifolium, T. carolinianum, T. cernum, T. filiforme, T. fragiferum, T. glomeratum, T. hirtum, T. lappaceum, T. lupinaster, T. medium, T. michelanium, T. nigrescens, T. pamonican, T. procumbens, T. resupinatum, T. sculatum, T. striata, T. subrotundum, T. subterraneum, T. tomentosum, T. variegatum, T. wormskjoldii,* and *T. xerocephalum*), and 2 other genera (*Medicago sativa* and *Ebenus cretica*) were susceptible. Seedlings of *Brassica oleracea* var. *bottrytis, Capsicum annum, Lotus corniculatus, Lupinus angustifolium, Lycopersicon esculentus,* and *Solanum melongena* failed to develop symptoms 3 weeks following inoculation.

Status of studies on developing lines of Pisum sativum resistant or tolerant to Fusarium root rot. KING, T. H., H. L. BISSONNETTE, AND H. G. JOHNSON. During the past 6 years, 391 Plant Introductory accessions of *Pisum sativum* were planted in 2 disease nurseries. One was on "pea sick" soil from which *Fusarium solani, F. oxysporum* var. *pisi* (form 2), and *Aphanomyces euteiches* have been isolated; the other was on land from which only the Fusaria causing root rot and wilt have been isolated. All lines that produced seed were replanted a second year and the most resistant lines selected. Of the 391 lines, 14 have been selected as resistant or tolerant to the root rot fungi existing in the field nurseries. As these lines were selected, crosses were made between them, and the progenies were increased and planted in the nurseries for further selection. Sixteen progeny lines of the crosses made from the 14 original resistant selections have survived better than the average of their parents. In 10 of these lines, the percentage survival of the progeny was greater than that of either parent. The lines are at present in the F_6 and F_7 generation. Several other lines in earlier generations appear promising.

Ringspot and other disorders of Pelargonium that are caused by graft-transmissible agents. KIVILAAN, A. Several types of symptoms developed in geranium (*Pelargonium hortorum*) seedling plants grafted with scions from standard varieties. These reactions apparently were of virus origin and included necrosis, necrotic ringspot, ringspot, crinkle, and mottle. There is no evidence to indicate that a single virus is involved. Under most conditions, the parent plants appeared to be normal, but known infected plants of some varieties sometimes had small leaves, mottle of lower leaves, or short internodes. Cuttings taken from lower portions of infected plants often developed definite necrosis, ringspot, crinkle, or mottle when growth resumed. Attempts to transmit the virus or viruses mechanically and by dodder were not successful. A procedure was developed to determine the presence of virus in propagating material. This assay consisted of veneer grafts of scions from suspect plants to stocks of highly sensitive clones. The disease appeared to be common, since assays of 100 plants each of 6 varieties from commercial sources showed an average

of 62 per cent infection. Virus-infected plants were more susceptible to bacterial blight than were virus-free plants.

A rapid method of screening of nematocides in the greenhouse. KLEIN, H. H., AND C. C. ALLISON. A rapid method of screening new chemicals as nematocides has been developed at the Ohio State University. A sand-loam-peat mixture is infested with adults, larvae, and eggs of *Meloidogyne* spp. from knotted roots of coleus, tomato, and cucumber plants. The infested soil is treated by adding the compounds to be tested and then placed in containers. For fumigants, the containers are covered for a short period with Saran Wrap. Following this period, 4-day-old Green Prolific cucumber seedlings are transplanted into chemically treated and into untreated soil. Root knot severity is assayed approximately 7 days after seedlings are transplanted and is determined on the basis of the percentage of the root system knotted.

Comparative effect of different osmotic pressures on Colletotrichum linicolum and on mutants induced by alpha radiation. KLUC, R. J. A parent line of *Colletotrichum linicolum* was grown on synthetic media of different osmotic pressures. Growth was greatly limited by increased pressures and finally terminated at 56 atmospheres. Mutants varied as to the osmotic pressures tolerated. Regardless of the initial color of the cultures on media of low osmotic pressures, all cultures were a bright orange on media of high osmotic pressures. Like the parent line, the degree of sporulation of most mutants decreased progressively as osmotic pressures increased and ceased at 10 atmospheres. Four distinct thallus types resulted on increasingly higher osmotic pressures, namely, filamentous, filamentous-beaded, beaded, and spheroid. The last type consisted of individual cells that increased by binary fission. Spheroid cells transferred to potato-dextrose agar germinated well. Freezing and drying did not affect their viability. Inoculated to Punjab flax, they proved to be as pathogenic as ordinary conidial types. Osmotic pressure fluctuations of the soil are such that this type of growth presumably could occur and give rise to unicellular fragments capable of surviving periods of reduced soil moisture.

Cellulolytic activity of mutants of Colletotrichum linicolum induced by alpha radiation from polonium^{210}. KLUC, R. J., AND J. T. THREINEN. Distinct differences have been noted in the cellulolytic activity of mutants of *Colletotrichum linicolum*. The parent line and mutants 4-1, 8, 19a, 23, 54, and 63a were grown in liquid synthetic media containing cellulose fibers as the sole carbon source and in a synthetic cellulose-glucose medium. All cultures grew well in the cellulose-glucose medium. In the cellulose medium, mutant 23 grew more prolifically than did the parent; mutants 8, 19a, and 54 grew equally well, and 4-1 and 63a grew less well. Little or no destructive effect was observed, with the polarizing microscope, upon cellulose fibers when the media contained glucose. Where cellulose was the only carbon source, mutant 23 was more destructive than the parent line; mutants 4-1, 19a, and 54 were equally as destructive; and mutants 8 and 63a were less so. The parent line and all mutants utilized glucose in preference to cellulose, but there were differences in their ability to utilize cellulose when it was the sole carbon source. Subsequent pathogenicity tests upon Punjab flax seedlings indicated that there was no correlation between cellulolytic activity and pathogenicity.

Sporangial germination and infection by isolates of Phytophthora infestans. KNUTSON, KENNETH, AND CARL J. EIDE. Sporangia of isolates of *Phytophthora infestans* differ widely in speed and final percentage of germination, the differences being greater at 10° and 15° than at 20° and 25°C. At the higher temperatures, there is little additional germination after 4 hours. When potato plants are inoculated with sporangia in the greenhouse at about 20°C, the first appreciable infection occurs about 4 hours after inoculation. Thereafter, the number of infections per plant increases with time, there being big differences in the speed of infection by different isolates. Such differences are found between isolates of the same or different pathogenic races. The differences in rate of infection do not seem associated with differences in rate of germination. The ratio of infections to concentration of sporangia in the inoculum suspension is fairly constant over a wide range of sporangial concentrations. Too many sporangia per unit volume tend to obscure differences between isolates, and too few increase the sampling error.

The role of quack grass in root rots of cereals. KOMMEDAHL, T., AND J. B. KOTHEIMER. Seedling stands of barley, oats, wheat, and corn were reduced substantially following inoculation in the greenhouse with species of *Curvularia*, *Fusarium*, *Gibberella*, and *Helminthosporium* that were isolated from rhizomes of quack grass, *Agropyron repens* (L.) Beauv. Depending upon the isolate, *Helminthosporium sativum* Pam., King, & Bakke reduced stands of Barbless barley 85 per cent, Vicland oats 75 per cent, Mindum wheat 100 per cent, and corn (Minn. 607) 70 per cent. The effects of adding ground, autoclaved rhizomes to soil (found to be similar, in general, to using soil cropped to *A. repens*) were as follows: 1) germination percentages of Selkirk wheat decreased as the amounts of ground rhizomes in soil was increased; 2) plumules of wheat seedlings failed to develop, or developed slowly, even though radicles grew normally; 3) heights of Selkirk wheat plants were reduced 30 per cent and those of Bonda oats 20 per cent below those of controls; 4) dry weights of oats and wheat plants averaged about ½ those of controls; 5) abnormal or stunted seedlings thus produced were more subject to blights and rots than were normal seedlings; and 6) when inoculum of *H. sativum* was added also, root rot on seedlings of Kindred and barley appeared sooner and was more severe than on plants with inoculum but without rhizomes.

The influence of root-knot nematodes on the growth of Porto Rico sweetpotato. KRUSBERG, L. R., AND L. W. NIELSEN. The influence of *Meloidogyne incognita acrita* on the growth, yield, and quality of Porto Rico sweetpotato was investigated. Land heavily infested with this nematode was divided into 4 50-ft. blocks, with 7 pairs of rows per block. One row from each pair was fumigated, 3 weeks before planting, with D-D (1,3-dichloropropene; 1,2-dichloropropane) at 20 gal. per acre, with vermiculite as the carrier. Plants in 1 pair of rows from each block were harvested 16 days after planting and others thereafter at 2-week intervals for 6 samplings, with a 7th sample taken after an interval of 4 weeks. A composite 1-pint soil sample for nematode assay was removed from each plot when harvested. The difference in nematode populations in treated and nontreated soil decreased until at 10 weeks after treatment, and thereafter, there were no differences. In comparison with plants grown in treated soil, those in nontreated soil had larger root-knot indices, smaller top and root weights, and fewer enlarging roots; in addition, roots formed were more severely malformed and cracked.

Increase of resistance to apple scab following injection of host with phenylthiourea and D-*phenylalanine.* KUC, J., E. B. WILLIAMS, AND J. R. SHAY. Organic compounds, selected for possible effects on the metabolism of the host or pathogen, were injected into potted apple trees resistant to Race 1 but susceptible to Race 2 of *Venturia inaequalis*. The compounds were fed through leaf petioles of actively growing shoots during a 24-hour period prior to inoculation. Resistance to both races was markedly increased after injection with solutions either of phenylthiourea or of DL- or D-phenylalanine. The naturally occurring L-phenylalanine was not active, suggesting that activity was due to

configuration. Isomers of phenylalanine were not inhibitory to the growth of the pathogen in culture at concentrations equal to or greater than those used *in vivo*. D-Phenylalanine can function to increase resistance either by serving directly as a precursor for a compound associated with resistance or by affecting the metabolism of the leaf tissue so as to induce a resistant environment. In the latter case, the compound itself would not be changed into an inhibitor, but its action on other compounds and/or enzyme systems could result in increased resistance.

Purple-stained soybean seed. KULIK, MARTIN M. Previous work has indicated that *Cercospora kikuchii* T. Matsu. & Tomoyasu, the incitant of the purple stain disease of soybeans, can be isolated from apparently healthy as well as from purple-stained seed; these findings were confirmed by the present study. It therefore seemed desirable to determine whether the number of visibly affected (purple-stained) seed in a given lot could serve as a valid index of the total number of infected seed in that lot. Tests that involved 189 separate lots of seed from 14 locations and in which the percentage of purple-stained seed ranged from 0.0 to 31.5 showed that in most cases the number of purple-stained seeds in a given lot varied directly with the number of infected, but apparently healthy, seed in the same lot. Thus, lots showing large amounts of purple-stained seed invariably contained large amounts of infected but nonstained seed, and *vice versa*.

Tree wounds and long-distance spread of oak wilt. KUNTZ, J. E., AND C. R. DRAKE. In experiments involving over 5,000 northern pin oaks, 4–12 in. dbh, in central Wisconsin, infections followed artificial inoculations with *Endoconidiophora fagacearum* from April through December. Natural infections, however, followed trunk wounding, usually during springwood-vessel development and leaf expansion. During woodland improvement, when inferior stump sprouts were removed during late May and early June, 23 per cent of the remaining stems became infected. Similarly, 19 per cent of 109 oaks pruned in mid-June became infected. Of 660 oaks on which trunk wounds were protected by insect-proof cages for different periods, all became infected following wound surface inoculations made up to 4 days after wounding; no infections occurred after 8 days. In contrast, natural infections occurred only within 24 hours of wounding. Of 960 trees severely wounded with ax cuts, 32 per cent of the May controls became infected. No trees with wounds painted immediately with liquid asphalt roofing compound or with house paint became infected.

The behavior of combinations of three small-grain viruses on wheat. LAL, S. B., AND W. H. SILL, JR. Both spring and winter wheat varieties were inoculated with 1:10 aqueous dilutions of sap of plants infected with wheat streak mosaic (WSMV), brome mosaic (BMV), and barley stripe mosaic (BSMV) viruses, alone and in all combinations. Symptoms of the resulting diseases and statistical studies of comparative dry weights indicated that the greatest effects were caused by BMV, followed in order by BSMV and WSMV. Of the combinations, BSMV + BMV produced the most severe effects, exhibiting extreme synergism and usually producing sterility and death. WSMV + BMV + BSMV was second but not statistically different from BSMV + BMV. The presence of WSMV in this combination seemed to reduce the severity slightly although not significantly. BMV + WSMV was third but not statistically different from BMV. No synergism was present, the severity of the reaction being that of BMV alone. BSMV + WSMV, the least severe combination, showed some synergism and was statistically different from BSMV alone. In all combinations, symptoms induced by BMV and BSMV tended to dominate those induced by WSMV. The individual viruses were reisolated from each combination in each test by the use of diagnostic hosts and the mite vector for WSMV, *Aceria tulipae* (K.).

The behavior of uredospores of Puccinia graminis var. tritici on the leaf surface. LEATHERS, CHESTER R. Uredospores of *Puccinia graminis* var. *tritici* applied to wheat leaves soon after collection maintained a high level of germination for several weeks in a controlled environment in the greenhouse (40 per cent relative humidity at 75°F). Beneficial effects of hydration persisted at least 40 days in spores that had been collected and hydrated (placed in a moisture-saturated atmosphere for 24 hours) prior to their application to the primary leaves of wheat. Germination of hydrated spores on the leaves of plants removed from the greenhouse at daily intervals and subsequently exposed to dew remained consistently between 70 and 90 per cent for the 40-day period; in contrast, nonhydrated spores maintained a level of germination above 50 per cent for about 3 weeks, after which their germination steadily decreased. The germination potential of uredospores subjected to several hours of dew at temperatures below 45°F in the field remained near maximum for 3 days. The germination potential of uredospores subjected to temperatures in the range of 30° to 70°F in the absence of dew also remained near maximum.

The effect of certain antibiotics on potato production and ring rot control in Alaska. LOGSDON, CHARLES E. When seed tubers inoculated with ring rot bacteria were treated with 1000 ppm Agri-mycin 100 (15 per cent streptomycin; 1.5 per cent oxytetracycline), 8 per cent of the hills had symptoms at harvest in comparison with 39 per cent for untreated controls. Agritracin (5 g bacitracin/lb.) had no significant effect. An additional 35 per cent of the hills grown from seed treated with Agri-mycin were found infected when examined after storage. This amount was significantly less statistically than that for the untreated check. When noninoculated potatoes were treated with Agri-mycin 100 at 5000 ppm, the yield was 3.2 tons per acre in comparison with a yield of 7.5 tons for untreated checks. This small yield was due to decreased stand, to a smaller percentage of U. S. No. 1 A tubers, and to a smaller size of the tubers of that grade.

Toxin production by Helminthosporium sativum and its role in pathogenicity. LUDWIG, R. A. The invasion of cereal seedlings by *Helminthosporium sativum* Pam., King, & Bakke is facilitated by toxic substances that it produces. Maximum growth of the organism in stir culture is achieved in 3–4 days on a suitable medium. This peak of growth coincides with maximum toxin production. The toxins are also antifungal and on rich media appear to be the primary factor limiting growth of the organism. The toxins persist for considerable periods in certain media but disappear very rapidly from others. The growth of cereal seedlings is strongly inhibited by the toxins. Plants treated with the toxin develop many of the symptoms of the disease and are highly susceptible to invasion by the fungus. Strains of the organisms differ both in their ability to produce toxins and in their ability to invade even in the presence of toxin.

Studies on the chemistry of the fungitoxicity of captan. LUKENS, RAYMOND J., AND SISLER, HUGH D. Various biochemicals were tested to determine their ability to antagonize the toxicity of captan (*N*-(trichloromethylthio)-4-cyclohexene-1,2,dicarboximide) to *Saccharomyces pastorianus* Hansen. Only compounds such as cysteine, homocysteine, and glutathione, which contain –SH groups, were effective antagonists. At pH 6.0, cysteine will detoxify captan when it is equivalent in molarity to the fungicide. Cysteine is ineffective when added 1 hour after addition of the fungicide. The reaction between captan and –SH compounds results in release of hydrogen ions. For each mole of captan, slightly in excess of 1 mole of hydrogen ions is produced per mole of –SH compound added until 3 moles are used. Further addition of –SH compound results in no appre-

ciable increase in release of hydrogen ions. The number of chloride ions released in this reaction is approximately equivalent to that of hydrogen ions produced. Cysteine destroys the trichloromethyl group of captan and thus may destroy the fungitoxic portion of the molecule or render it unable to penetrate the cell membrane. The results suggest that a reaction between captan and –SH groups within the fungal cell may account for captan toxicity or may be the mechanism for release of the toxic products of captan within the cell.

Cross-protection studies of two types of corn stunt virus. MARAMOROSCH, KARL. The viruses of 2 distinct types of corn stunt disease, previously designated as Rio Grande and Mesa Central, were acquired in feeding periods of 1 day and transmitted after an incubation period of 2–3 weeks by either *Dalbulus maidis* or *D. elimatus*. When individuals of *D. maidis* first acquired the Mesa Central type and 2 weeks later the Rio Grande virus, they transmitted the Mesa Central type first and the Rio Grande later. When Rio Grande virus was acquired first, only it was transmitted. Similar results, with very few exceptions, were obtained after a 7-day interval between virus acquisitions. A 1-day interval resulted in the initial transmission of either type, irrespective of the order of acquisition; in subsequent weeks, Rio Grande virus was transmitted predominantly and finally exclusively. In plants simultaneously infected with both viruses, symptoms of Mesa Central disease often were observed in the beginning; later the more severe Rio Grande disease developed. The fact that the Rio Grande virus protected against Mesa Central virus indicates strain relationship. Rio Grande virus may move or multiply faster than the other, pre-empting certain insect and plant tissues and thus suppress transmission or multiplication of the Mesa Central virus.

Effects of temperature on spore germination and host infectivity by three strains of Colletotrichum lindemuthianum. MARTINEZ SALAZAR, EUGENIO, AND AXEL L. ANDERSEN. The optimum temperature for germination of spores of *Colletotrichum lindemuthianum* was 28° C. Alpha, beta, and gamma strains started to germinate in 9 hours at this temperature. The beta strain began to germinate after 7½ hours at 24° C. The beta and gamma strains had a wider optimum temperature range for germination than did strain alpha. For example, after 24 hours at 16°, 20°, 24°, 28°, and 32° respectively, percentage germination of the alpha strain was 0, 8, 5, 90, and 9; that of beta was 19, 39, 32, 93, and 25; and that of gamma 6, 24, 62, 96, and 25. Studies at 10°, 15°, 20°, 25°, and 32° indicated that 25° was optimum for infection of Michelite bean by strain alpha and of Dark Red Kidney bean by the other 2 strains. Infection was established in 12 hours at this temperature. No infection was obtained with any of the 3 strains after 72 hours at 10° or 32° in the inoculation chamber.

Three genetic abnormalities in the sweetpotato variety Porto Rico. MARTIN, W. J. Three different clonal lines were established from abnormal plants collected in commercial fields of the Porto Rico variety of sweetpotatoes in Louisiana. One of the clones was started from a plant with leaf variegation, which is not uncommon in sweetpotatoes; the second clone was established from a plant with crisp, crinkled leaves; and the third clone came from a plant with severely cupped leaves. Each of the 3 abnormalities persisted when the clones were propagated asexually and were suggestive of symptoms caused by certain viruses, particularly in the case of the last 2 mentioned above. Attempts to transmit agents causing these abnormalities by cleft-grafting normal plants on the 3 clones, or by grafting the abnormal clones on healthy plants, were not successful. Therefore, the abnormalities were considered as being of genetic and not of virus origin. Storage roots produced by the 3 abnormal clones were not widely different in appearance from those produced by normal plants of the Porto Rico variety.

A study of potato spindle tuber by paper chromatography. MCANELLY, CHARLES W. Selections of normal-appearing and spindle tuber affected tubers of a potato seedling were selected at digging time. The eyes of each tuber were removed, placed in separate Petri dishes, and quick-frozen. After thawing, the juices were extracted and used for 1- and 2-dimensional ascending chromatograms. Determinations of the amino acids and protein pattern were made and compared. The glutamine and glutamic acid contents of the tubers infected by spindle tuber virus appeared higher than those of the normal-appearing tubers. The total amount of protein, as well as the number of protein fractions, was found to be greater in the infected tubers than in the healthy tubers.

Effect of fungicides on oxygen consumption and viability of mycelium. MCCALLAN, S. E. A., AND LAWRENCE P. MILLER. Mycelial pellets of *Alternaria oleracea, Aspergillus niger, Monilinia fructicola,* and *Myrothecium verrucaria* are physiologically much less active than are spores, as shown by less oxygen consumption. At the highest concentrations tested, cadmium, zinc, cerium, and arsenate were without effect on either oxygen consumption or viability of mycelial pellets. With pellets, silver, copper, mercury, and malachite green generally gave ED_{50} values (based on external concentration) for O_2 consumption equal to or lower than those for viability. This was in contrast to the opposite response with spores. Viability of pellets decreased with increasing time of exposure to silver or mercury; toxicity doubled with each 3-fold increase in time. Generally, mycelium was more sensitive to fungicides than were spores when sensitivity was determined by data on O_2 consumption; the difference was much less when viability was the criterion. Studies with radio-active fungicides showed that the uptake of silver and of dichlone by pellets was slow compared to that by spores but that it increased with time. ED_{50} values for viability were comparable for pellets and for spores. Comminuted pellets took up silver more rapidly than did undamaged pellets despite a greatly reduced O_2 consumption. There was no measurable uptake of cerium or zinc by *A. niger,* although the spores have a marked affinity for cerium.

A ringspot virus on greenhouse cucumbers in Ontario. MCKEEN, C. D. Since 1952, a virus disease of the tobacco ringspot type has affected crops of greenhouse cucumbers in Ontario. The most pronounced symptoms, which are almost completely masked during the hot summer months, occur on the foliage and less frequently on the fruit. Symptoms are similar to those caused by certain strains of tobacco ringspot virus (TRV); however, strains of the TRV commonly encountered on tobacco and soybean in Ontario have not afforded protection against a later infection by the cucumber ringspot virus (CRV). Of numerous hosts inoculated, only cucumber is completely systemically invaded by CRV, and even in this host frequently more than 60 per cent of inoculated plants show incomplete systemic invasion. Soon after the inoculation of the cotyledons of young cucumber plants, the virus enters the roots and frequently remains there for 6 weeks or longer at a moderately high concentration with no expression of symptoms in aboveground parts or evidence of movement into them. Similarly, after inoculation of cantaloupe, watermelon, and squash, CRV reaches the greatest concentration in root tissue. Greenhouse tests indicate that cucumbers may become infected through their roots. Evidence supporting seed transmission of the virus in cucumber has also been obtained.

Pathogenic strains of tobacco mosaic virus on tomato. MCRITCHIE, JOHN J. In the breeding of tomatoes for resistance to the tobacco mosaic virus, it was observed that tomato line CStMW-18 (obtained from J. M. Walter) and

certain of its hybrid derivatives did not become infected following some inoculations but did so following others. Because of these erratic results, a study of pathogenic strains of the virus was initiated. Viruses from 10 sources were purified by ultracentrifugation and inoculated to 9 varieties and species of tomato. The virus strains differentiated into 3 pathogenic groups. Those in Group 1 produced no visible symptoms on line CStMW-18, and the plants were free of virus. Check plants of standard varieties exhibited visible symptoms. Those in Group 2 produced no visible symptoms on line CStMW-18, but on assay the plants were found to contain virus, as did the check plants. Those in Group 3 produced visible symptoms on line CStMW-18 as well as on check plants. By the use of line CStMW-18 and 2 standard varieties, it was possible to differentiate the strains. The results were repeated with single-lesion isolates of the strains. To eliminate the possibility that the presence of other viruses was responsible for these results, samples of each group were heated to 85°C for 10 minutes. Heated viruses still produced the same results.

Effect of strains of tobacco mosaic virus on yields of certain tomato varieties. McRITCHIE, JOHN J., AND LEONARD J. ALEXANDER. In a program on breeding for resistance to tobacco mosaic virus (TMV), J. M. Walter's nonsymptomatic tolerant line CStMV-18 was used as the resistant parent. It was desirable therefore, to determine the effect of TMV on the yield of this line. In the summer of 1954, plots were planted and the plants inoculated June 15 and July 15 with a wild green strain of TMV. Following inoculation, plants of all standard varieties developed symptoms, but those of line CStMV-18 remained symptomless. Repeated inoculation of plants of this line failed; the plants were virus free upon assay. Consequently, all plots of line CStMW-18 yielded similarly whereas the yield of plots of Rutgers, W-R Globe, and W-R Brookston was depressed 13, 3 and 12 per cent, respectively, following the June 15th inoculation. During the following summer, a similar test was established; again, a wild green type from the greenhouse was used as inoculum. All the tomato lines became infected, including the previously resistant line. The yield of line CStMW-18 was 38 per cent less than that of the noninoculated checks, whereas the above-named standard varieties were reduced in yield by 27, 21 and 13 per cent, respectively, following the June 15th inoculation. These results further confirm the existence of pathogenically differing strains of TMV and show that they affect yields in varying degrees.

Factors influencing soil mycofloras. MENON, S. K., AND L. E. WILLIAMS. Some of the factors that may be operative in inducing changes in mycofloras in the field were investigated in the laboratory and greenhouse. A soil-dilution-plate technique was used for the isolation of fungi. Fungi were identified to genus, except that Aspergilli were identified to the groups proposed by Thom and Raper and Penicillia to the series proposed by Raper and Thom. Mycofloras of soil after 4 successive croppings of alfalfa, corn, oats, and wheat were different. Highest numbers of colonies of *Penicillium funiculosum* series and of *P. purpurogenum* series were isolated from corn soil, Fusarium colonies were highest in alfalfa soil and lowest in corn soil, and highest numbers of colonies of Rhizopus were associated with wheat. The mycofloras of soils cropped to corn or oats were different from those of soils amended with their residues. Soil moistened daily to field capacity and maintained at 10°, 20°, or 30°C did not differ in the qualitative or quantitative nature of the mycofloras. After 7 weeks, there were differences in the mycofloras of soils watered at different time intervals and whose moisture contents fluctuated between 20 and 8, between 20 and 14, or between 20 and 18 per cent by weight. The number of colonies of Botrytis, of *Penicillium restrictum* series, and of total Penicillia decreased with increase in moisture.

Studies on phenotypic variability and identification of subraces within race 29 of Puccinia graminis var. tritici. MILLER, JAMES D. Twenty-eight isolates comprising phenotypes of the closely related races 17, 29, and 37 of *Puccinia graminis* var. *tritici* furnished by the Cooperative Rust Laboratory at St. Paul, Minnesota, were tested on the standard differential wheat varieties at about 65° and 85°F, and 13 were tested at 75°F also. All produced the distinctive infection type X of race 29 on the durum varieties at 65° and 75° but not at 85°, where they resembled race 17. Genetically, all were therefore race 29, but they comprised at least 4 subraces that can be distinguished by the use of 2 additional wheat varieties (durum C.I. 3255 and one of the common wheats Bowie, Travis, or Selkirk) which were selected as additional differentials from 18 varieties tested for the purpose. The durum is susceptible to 2 of the subraces and resistant to the other 2. Each pair in turn can be separated by the effect on either Bowie, Travis, or Selkirk, but only at temperatures below 70°F.

Factors associated with the toxicity of mercury to fungus conidia. MILLER, LAWRENCE P., AND S. E. A. McCALLAN. Next to silver, mercury is the metal ion most toxic to fungus spores; however, ED_{50} values on a spore-weight basis are quite high. Values based on the quantity removed from solution are somewhat higher than the true ones because spore supernatants contain substances that precipitate some of the mercury supplied. When copper or silver ions, which would be expected to compete for some of the same receptor sites as mercury, are added with mercury, there is an apparent increase in the uptake of mercury. This follows because copper and silver affect the permeability of the cell walls, and contents are released that precipitate mercury. Hg^+ and Ce^{+++} ions interfere with the uptake of mercuric ions. Hg^{++} taken up is released more readily on the addition of Hg^+ than on addition of Hg^{++} ions. Apparently, Hg^+ ions play an important role in the toxicity of mercury. The addition of equivalent quantities of iodide to mercuric nitrate or acetate increases the toxicity of mercury many fold, when expressed either on a spore-weight basis or as the concentration of the applied solution.

Importance of fungicide volatility in controlling soil fungi. MILLER, P. M., AND E. M. STODDARD. The role of volatility in control by fungicides of soil-inhabiting fungi was determined by testing several fungicides against *Rhizoctonia solani*, *Botrytis cinerea*, *Fusarium* sp., and *Thielavia basicola*. To keep the fungicides from direct contact with the fungi, 100-mg, 50-mg, 10-mg or 2-mg samples of the fungicide were placed in aluminum foil cups set on aluminum platforms above potato-dextrose agar in 55-mm glass petri dishes. Mercurial fungicides were of necessity placed in glass containers. The fungi were seeded on the agar surface, and the dishes were kept covered. Mycelial growth was rated from 10 (normal growth) to 1 (barely visible growth). Ceresan M (7.7 per cent *N*-(ethylmercuri)-*p*-toluenesulphoanilide) and *o*-nitrochlorobenzene (25 per cent formulation) were highly effective in a volatile state against all the fungi. Pentachloronitrobenzene (75 per cent formulation) was moderately effective against *B. cinerea* and *R. solani* but not against Fusarium or *T. basicola*. Captan, Puratized Agricultural Spray (7.5 per cent tri(2-hydroxyethyl)(phenylmercuri) ammonium lactate), chloranil, and some experimental materials were partly effective against 1 or more of the fungi. Thiram and other dithiocarbamates were inactive. All soil fungicides tested act to some extent in a volatile state.

Dispersal of spores of Botrytis cinerea among strawberries. MILLER, P. M., AND P. E. WAGGONER. The influence of environmental conditions on dispersal of spores of *Botrytis cinerea* on strawberries was studied with a Hirst spore trap. The trap was located in a ½-acre field averaging 10 infected berries per foot of row. Continuous records were kept of temperature, humidity, and rainfall. Wind velocity

and observations on haze or fog were obtained from the nearest weather station. The number of spores/m^3 at a height of 18 in. was found for each hour of 10 days. This period included 2 rains, 1 foggy day, 3 foggy nights, and 1 gusty day. Most spores were caught in periods of high humidity, regardless of rain or time of day. Only occasional spores were caught under other conditions. The highest count was 112 Botrytis spores/m^3, which is a comparatively low figure. For example, air-borne ascospores of *Venturia inaequalis*, during conditions favorable for discharge, reached a high count of 21,000 spores per m^3. This comparison suggests that most infections by *B. cinerea* originate from nearby primary inoculum and that the microclimate afforded by the dense strawberry foliage is more important than environmental conditions above the plants in determining incidence of gray mold.

Symptoms of scar skin in apple. MILLIKAN, D. F. Scar skin, a disease first reported in 1955, was found in several orchards in Missouri during the 1956 growing season. In early June, when the apples were slightly less than ½ in. in diameter, light water-soaked blemishes appeared, radiating from the calyx end of the fruit. Two weeks later, when the apples were ¾ in. in diameter, scar tissue developed in the epidermis, especially around the calyx. By July, when the fruits were over 1 in. in diameter, irregular patches of epidermal scar tissue developed on the sides of the fruits. Later, as much as 50 per cent of the fruit surface was affected. On the affected trees, every fruit had symptoms as described. Throughout the growing season, fruits from the affected trees were markedly smaller than fruits from the adjoining unaffected trees.

Chemical inhibition of necrotic ring spot in plum. MILLIKAN, D. F., AND H. W. GUENGERICH. In 1954, rapidly growing shoots of a plum tree systemically infected with ring spot virus were treated from bud break until early July with thiouracil at a concentration of 140 ppm, with 8-azoguanine at 100 ppm, or with both in combination. Treatment consisted of wrapping cotton pads about the base of the shoot to be treated and saturating these pads at weekly intervals with 50 ml of the chemicals. These cotton pads were covered with polyethylene sleeves securely tied at both ends with string. A total of 11 buds from shoots treated with 8-azoguanine, 12 from thiouracil-treated shoots, and 38 from shoots treated with both were propagated. In 1955, these buds developed into remarkably vigorous trees, which were tested for the ring spot virus on Shiro-fugen flowering cherry. Two trees each from the thiouracil and the 8-azoguanine treatments produced no ring spot reaction when indexed on the indicator plants. These same trees were tested in 1956 on Montmorency, on *Prunus tomentosa*, and on Lovell peach; again, there was no indication of infection by ring spot virus. All trees, including those free of ring spot virus, showed the mottled leaf pattern of the parent trees. This was thought to be constricted mosaic. None of the trees developing from the combined treatment were free from ring spot virus.

Blight resistance of selected Solanum hybrids in Mexico. MILLS, W. R., JOHN S. NIEDERHAUSER, AND R. W. HOUGAS. Crosses were made between clones of *Solanum demissum* (hexaploid) selected for high resistance to *Phytophthora infestans* and 15 blight-susceptible diploid species of *Solanum*. The resulting F_1 hybrids were crossed to *S. tuberosum* var. Katahdin, and to *S. stoloniferum*, a tetraploid species moderately resistant to blight in Mexico. Four tubers each of 110 F_1 selections, 69 crosses with Katahdin, and 50 backcrosses with *S. stoloniferum* were planted at Toluca, Mexico. Blight readings were made in July and August, on a scale of 0 (no blight) to 5 (plants killed). None was immune. High resistance (rating of 1 or 2) was noted in 66 per cent of the F_1 selections. Progeny of the $F_1 \times$ Katahdin backcross were mostly susceptible, 84 per cent being rated 4 or 5. Nine per cent were rated 2 and none rated 1. Backcrosses with *S. stoloniferum* were about as resistant as the F_1 parents, and in several instances, resistance was enhanced. Sixty-four clones of *S. andigenum* were all susceptible with ratings of 4 and 5.

Changes in tobacco mosaic virus in Lycopersicon peruvianum. NAGAICH, B. B., AND H. H. THORNBERRY. Of the 160 plants of tomato accession No. 212407 of *Lycopersicon peruvianum* mechanically inoculated with tobacco mosaic virus (TMV), 70 remained without symptoms or contained no virus detectable by assay on *Nicotiana glutinosa*. The remaining 90 plants developed symptoms and contained virus detectable on *N. glutinosa*. Assays from 10 of the diseased plants of *L. peruvianum* on a battery of indicator plants showed the following: virus in all 10 sources caused mottling of Turkish tobacco, that in 1 source produced necrotic local lesions on Pinto beans, and that in 3 sources caused necrotic local lesions on table cowpeas. The noninfected Pinto bean plants developed necrotic local lesions from reinoculation with original TMV. Reassay of the 10 diseased plants of *L. peruvianum* on half leaves of Pinto beans gave results identical to those of the first assay. According to assays on opposite half-leaves, the diseased Turkish tobacco plants contained virus identical to that in the corresponding plants of *L. peruvianum*. The opposite leaves were susceptible to the original TMV. Thus detectable viral changes occurred in *L. peruvianum* but not in Turkish tobacco. The observed changes apparently are due to alterations in the original virus rather than to contaminations with TMV strain 52.1 or to selections from a mixed population of TMV.

The establishment and growth of Fusarium lini in flax tissues. NAIR, P. N., AND T. KOMMEDAHL. Infected seeds of Punjab flax as well as roots of wilted plants were examined histologically to find the mode of infection by *Fusarium lini* Bolley. Seedlings were immersed in spore suspensions, incubated, then sectioned. Hyphae entered root hairs of the susceptible variety Punjab and were abundant in both xylem and phloem, but only phloem tissues were disintegrated. *F. lini* was present in the cortex but not in the vascular tissue of the resistant variety Redwood. Injured and noninjured seed of Punjab flax were dipped in inoculum of *F. lini* and incubated for 48 hours; the pathogen was observed to enter the micropyle of noninjured seeds and through wounds of injured ones, and the cotyledons were invaded. Stands of 3 wilt-resistant varieties grown in a wilt nursery in the field from injured seed were less than ½ those from sound seed.

Further studies on extracts from germinating urediospores of Puccinia graminis var. tritici. NATOUR, R. M., AND HELEN HART. Distilled water extracts from germinating urediospores of race 15B of *Puccinia graminis* Pers. var. *tritici* Eriks. & E. Henn., similar to buffer solution extracts reported by Swaebly, were injurious to wheat mesophyll cells when introduced into wheat seedlings by partial vacuum. The toxic substance was obtained from broken and from unbroken germ tubes of spores but not from ground dead spores. Washings from freshly collected viable spores and from dead spores did not yield the toxic substance. The crude extract was inactivated by freezing for 10 days and by heating at 80–85°C for 10 minutes. Its activity was lowered only slightly by storage for 2 months at 3–5°C. Toxic effects were general rather than specific, i.e., they appeared on both susceptible and resistant wheats. Nevertheless, chlorosis and necrosis developed more rapidly and severely in Selkirk wheat than in Little Club and were more extensive and pronounced at 85–90°F than at 70–75°F. Germination of urediospores of race 15B and growth of such fungi as Alternaria, Aspergillus, and Penicillium or of black chaff bacteria were not inhibited by these extracts.

Resistance in corn to Meloidogyne incognita. NELSON, R. R. Corn inbreds and single crosses were tested for their

reaction to the root-knot nematode, *Meloidogyne incognita*. The evaluation of lines of corn for resistance was based on numbers and size of galls produced, on the amount of reproduction that occurred, and on a comparison of total root weights of plants grown in sterilized soil with those grown in soil infested with the nematode. Certain inbreds appeared to have some resistance in that only a few small galls were produced and reproduction was limited. Other inbreds were highly susceptible, as evidenced by the formation of many large galls and excessive reproduction. Each single cross tested was at least as susceptible as the most susceptible inbred that comprised it. Susceptible inbreds exhibited definite loss in root weights. Certain inbreds, which were heavily galled, showed little or no loss in root weights, indicating that these lines might be tolerant.

Variability in degree of compatibility of isolates of Cochliobolus heterostrophus. NELSON, R. R. *Cochliobolus heterostrophus* (*Helminthosporium maydis*), is heterothallic, in that monoconidial isolates are self-sterile and cross fertile. Isolates represent 2 distinct compatibility groups (A and a) and exhibit complete intergroup fertility and some intragroup fertility. Relative frequency of infertile crosses with known compatible isolates, position of perithecia produced in relation to component isolates involved, and frequency of fertile intragroup matings demonstrate that isolates within a compatibility group differ from one another in degree of compatibility. Within compatibility group A, isolates involved in the lowest percentage of infertile intergroup matings were those that nearly always produced the perithecia on their side of the mating, regardless of the compatible isolate with which it was paired. Isolates in group A involved in the highest percentage of infertile intergroup matings were those that seldom supported perithecial development on their side of the cross. One of the least fertile or one of the most fertile isolates usually was involved in an intragroup fertile mating. These studies suggest that factors for compatibility may be influenced directly by modifying factors.

Electrophoretic displacement of the necrotic area from the region of mycelial development in Khapli emmer infected with race 56 of Puccinia graminis var. tritici. OLIEN, C. R. If a toxin is responsible for the necrotic fleck symptom in wheat infected by the stem rust fungus, it might be a reactive molecule carrying an electric charge. Such a material should migrate in an electric field under proper conditions. Electrical contacts were made at 2 primary leaf tips in a pot of Khapli emmer infected by race 56 of *P. graminis* var. *tritici*. A current of 2–4 microamperes traveled down 1 leaf, through the roots to the soil, then up the second plant. A current applied when rust flecks appeared (4–5 days after inoculation) and continued for 2–5 days caused displacement of the necrotic area from the region of mycelial development toward the positive pole. No displacement occurred if a current was applied earlier than 1 day before flecking, later than 1 day after flecking, or to a wheat plant infected by a race not normally producing a necrotic fleck. Lack of migration when current was applied late, after distinct necrotic areas formed, was due to divergence of current around necrotic areas. Results indicate that a charged molecule produced during the host-fungus interaction induces the necrosis.

Effects of vitamins on the mycelial growth and conidial production of Hypoxylon pruinatum. OSHIMA, N., AND D. W. FRENCH. *Hypoxylon pruinatum* isolated from quaking aspen (*Populus tremuloides*) grew very poorly in synthetic media containing inorganic salts, asparagine, and dextrose. The fungus grew very well with the addition of thiamine (100 μg per liter), biotin (5 μg per liter) and pyridoxine (1 mg per liter) to the basic medium. Conidia were produced by 1 isolate when thiamine and biotin were added to the synthetic medium; if pyridoxine and nicotinic acid were added to this combination, the conidial production was twice as great as when only thiamine and biotin were added. Another isolate produced practically no conidia when first cultured on the basic medium plus thiamine and biotin. When this isolate was subcultured on the same medium, however, conidial production was as great as by the first isolate and addition of pyridoxine and nicotinic acid did not increase it.

Effects of viruses on overwintering of red clover in Minnesota. OSHIMA, N., AND M. F. KERNKAMP. Midland red clover plots were inoculated separately with pea streak, pea stunt, and pea mosaic viruses and with a mixture of the 3 in 1954 and 1955. In 1954, attempts to keep the check plots free from viruses failed, and the infection in individual plots ranged from 24 to 81 per cent. In April, 1955, virtually all plants in the entire nursery were dead, whereas other nurseries in the vicinity sustained no winter killing. In 1955, the test was repeated. Aphids were controlled by judicious spraying with malathion, and infection in the plots was 5, 54, 53, 67, and 62 per cent for the check, pea streak, pea stunt, pea mosaic, and the mixture, respectively. In the spring of 1956, the survival in the same plots was 97, 60, 70, 60, and 51 per cent, respectively. Mean yields (15 per cent moisture) in 1956 for the same plots (3.3 $\times$ 10 ft.) were 0.81, 0.71, 0.75, 0.57, and 0.38 tons per acre, respectively. The incidence of root rot was 96, 93, 91, 94, and 95 per cent, respectively, in these plots. In other plots on the experimental farm, there was no virus infection and no winter killing.

Effect of methods of soil infestation on the pathogenicity of three fungi associated with red clover root rot. OSTAZESKI, STANLEY A., AND J. W. GERDEMANN. The pathogenicity of *Fusarium solani*, *F. oxysporum*, and *Gliocladium roseum* on red clover seedlings was tested by comparing 5 methods of incorporating the test organisms with the soil. The methods used were 1) spore suspension, 2) spore suspension plus agar substrate, 3) substrate of whole oats, 4) substrate of sterilized potting soil, and 5) substrate of cornmeal-sand. Numbers of surviving seedlings at the end of 1 month were used as a pathogenicity index for each method. *F. solani* was more pathogenic than either *F. oxysporum* or *G. roseum*. *F. solani* and *F. oxysporum* were highly pathogenic when whole oats or cornmeal-sand was the inoculum substrate. Little or no pathogenesis resulted from the other treatments. When red clover seedlings were grown in sand culture in which agar and mycelium had been incorporated, the above 3 fungi and an isolate of an air-borne *Aspergillus* sp. proved pathogenic. Contaminants in the potato-dextrose agar check induced symptoms as severe as did the test organisms. The *Aspergillus* sp. caused a light brown root discoloration and a severe stunting and distortion of the surviving plants. *F. solani*, *F. oxysporum*, and *G. roseum* each caused a severe brown-to-black root rot. The last 3 organisms differed in their effects primarily in the degree of stunting they induced.

Pathological histology of wheat seed invaded by species of Aspergillus that cause deterioration of stored grain. PAPAVIZAS, G. C. Wheat seeds free of molds and seed inoculated with *Aspergillus glaucus* and *A. candidus* were stored for 40 days at 80 per cent relative humidity and 25°C. At intervals of 5 days, seeds were removed, fixed, sectioned, stained, and examined microscopically. Mycelium penetrated the outer cell layer of the coleorhiza and coleoptile within 10–20 days, gradually penetrated deeper, and invaded the embryonic tissues in mass within 30–35 days. Eventually, the radicles were separated from the mesocotyl by advancing masses of mycelium; in many cases, the tunica of the shoot apex was completely disorganized by mycelium. Development of the discoloration typical of germ-damaged or diseased wheat coincided with mass invasion of embryonic tissues by the fungi. No mycelium and no alterations in structure were observed in

the noninoculated fungus-free seeds stored under the same conditions of temperature and moisture.

Pathogenicity of species of Aspergillus in stored wheat. PAPAVIZAS, G. C., AND C. M. CHRISTENSEN. Wheat free of fungi that cause storage deterioration was inoculated with species of *Aspergillus* and *Penicillium* known to cause deterioration and stored for 2–7 months at 25°C and at relative humidities of 75, 80, 85 and 92 per cent in equilibrium with moisture contents of 14.6, 15.9, 17.0, and 20.0 per cent, respectively. Germination percentage of those samples free of storage fungi decreased very little or not at all, and no germ-damaged or diseased seed developed in them. Germination of those inoculated with various species of *Aspergillus* decreased drastically, and many of the dead seeds developed the dark germ color typical of diseased or germ-damaged seed. Inoculations with mixtures of spores of the various storage fungi tested did not reduce germination faster or increase diseased wheat faster than did the more pathogenic individual fungi of the mixtures, when used alone. Eight different isolates of *Aspergillus candidus* differed markedly from one another in pathogenicity on stored wheat.

Antibiotics delay oak wilt symptoms on inoculated northern pin oaks in central Wisconsin. PHELPS, W. R., J. E. KUNTZ, AND A. J. RIKER. Tests on 750 oaks (3–10 in. dbh) were made with 21 antibiotics to determine their effects on symptoms of oak wilt (incited by *Endoconidiophora fagacearum*). The materials entered by the chisel-cone method 24 hours before wound inoculations were made 2 ft. below the cone. Oligomycin, Acti-dione (cycloheximide), and the acetate derivative of the latter delayed symptom expression in over ½ the trees for at least 3 months. Of the controls, 95 per cent showed wilt within 1 month. Acti-dione and its acetate derivative were phytotoxic. Of 263 trees, only 50 per cent given oligomycin (50 ppm in 500 ml water) before inoculation showed symptoms within 2 months as compared to 90 per cent of the controls and of the trees treated after inoculation. In 147 trees with step increases of oligomycin to 760 ppm, only 30 per cent of the heavily treated trees (but 100 per cent of the controls) showed symptoms within 2 months. In 147 trees, the delay from oligomycin was roughly correlated with the number of chisel cuts; e.g. 2 cuts resulted in 70 per cent infection within 6 weeks and 6 cuts in 20 per cent. In 126 trees, inoculations made 1 ft. above the chisel cuts gave 10 per cent infection after 6 weeks, whereas those made elsewhere gave about 50 per cent. The controls gave 100 per cent.

The persistence of Systox in oat plants and its effect on the transmission of yellow-dwarf virus. PIZARRO, A. C., AND D. C. ARNY. The persistence of Systox (21.2 per cent demeton) in oat plants was determined by applying the chemical to the plants in various ways and then placing apple-grain aphids (*Rhopalosiphum fitchii* Sand) on the plants at certain intervals. When used as a soil drench, Systox at concentrations of 1:400 and 1:800 gave protection from aphid infestations for 4–5 weeks. At a concentration of 1:1600, the protection lasted only 1 week. When the Systox was applied as foliage spray, the plants were protected from aphid infestation for 7 and 5 days when the concentrations were 1:200 and 1:400, respectively. The toxicity of 1:1600 concentration was slight to nil 24 hours after application. When Systox in a charcoal carrier was applied to seeds, the plants that developed were toxic to the aphids for 14–18 days after planting. Viruliferous aphids were able to transmit yellow-dwarf virus even though they remained alive for only a few hours after being placed on the Systox-treated plants.

Strain differences in Pseudomonas sesami and the effect of a secondary organism on symptom expression on sesame. POOLE, D. DONALD. Species of *Pseudomonas* and of *Xanthomonas* were isolated from lesions on previously resistant B-1 selections of sesame. The Pseudomonas isolate was found to correspond closely to *P. sesami*, differing only in pigment production and sucrose utilization. The Xanthomonas apparently has not been previously reported. Isolates of *P. sesami* tested were found to fall into 3 groups based on their virulence on a selected set of differential varieties. These groups were designated strains I, II, and III. Only strain III produced lesions on previously resistant B-1 selections. The species of *Xanthomonas* was shown to function as a wound pathogen that enters with or after *P. sesami*. The interaction of the least virulent strain (I) of *P. sesami* and the species of *Xanthomonas* also resulted in the production of lesions on sesame varieties resistant to strain I alone.

Effect of thiouracil on tobacco plants infected with cucumber mosaic virus and on noninfected tobacco plants. PORTER, CLARK A., AND LEONARD H. WEINSTEIN. Tobacco plants of the variety Vamorr 48 systemically infected with cucumber mosaic virus and comparable noninfected plants were grown in nutrient cultures containing 0, 3, and 5 ppm of thiouracil and examined for changes in major biochemical constituents. Differential treatments were employed to facilitate evaluation of the individual effects of thiouracil and cucumber mosaic virus on the plants and to determine the effectiveness of thiouracil in inhibiting virus synthesis. Thiouracil treatment was initiated 48 hours prior to inoculation with virus and was continued for 7 additional days. Clear-cut differences were produced by thiouracil treatment in both infected and noninfected plants. As the concentration of thiouracil was increased, the concentration in leaf tissues of nonketo acids of the Krebs cycle and of nucleic acids decreased, whereas that of free amino acids and of amides increased. In infected plants, these changes were accompanied by a decrease in the amount of active virus.

Suppression by two substituted carbamates of symptoms induced by southern bean mosaic virus. PORTER, F. M., B. C. SMALE, W. H. PRESTON, JR., AND J. W. MITCHELL. A study of the effects of antibiotics and other compounds on virus-infected plants demonstrated that certain substituted carbamates suppressed symptom formation in Pinto bean stems freshly inoculated with southern bean mosaic vrius. Application of either furfuryl 5-chloro-2-methylcarbanilate or furfuryl carbanilate in lanolin immediately following stem inoculation resulted in almost complete suppression of symptoms without apparent injury to the plants. A "2-phase" carrier system composed of 1 volatile and 1 nonvolatile carrier proved satisfactory for treatments prior to inoculation. Use of furfuryl 5-chloro-2-methylcarbanilate in this carrier system either before or immediately after inoculation resulted in complete suppression of symptoms. The effect was, however, associated with slight localized injury of the stem.

Pathogen-suscept relations of Phytophthora parasitica var. nicotianae in roots of certain tobacco varieties and Nicotiana species. POWELL, N. T., AND C. J. NUSBAUM. Cytological studies were made of infections by the black shank fungus in roots of suscepts representing a wide range of resistance levels. The suscepts included *Nicotiana longiflora* and *N. plumbaginifolia*, as well as the following varieties or breeding lines of *N. tabacum:* Virginia Gold, Dixie Bright 101, Coker 139, Burley 11A, Rg, and 3548D. Four strains of *Phytophthora parasitica* var. *nicotianae*, which differed in their relative pathogenicity, were used. Roots were killed and fixed 24 hours after inoculation with zoospores. All strains of the pathogen readily entered the roots of each suscept, but there were marked differences in the extent of cortical penetration by different strains on any one host. Correspondingly, suscepts usually differed in their responses to invasions by different strains. Hypersensitive reactions, involving rapid cellular degeneration and reduced vigor of the pathogen, were observed in some

cases. A more congenial pathogen-suscept relationship existed in infections where the fungus colonized the host tissue extensively. Suberization of cortical cell walls occurred in most infections, apparently as a response to fungus invasion.

Differential corrosiveness to metal of seed-treatment fungicides. PURDY, LAURENCE H. Corrosion of seed-treating machines by fungicides is a prime factor associated with their durability. A study was designed to determine if seed-treatment fungicides used for wheat smut control in the Pacific Northwest are equally corrosive to the metal parts of a slurry machine. Painted or galvanized strips of metal of the type used in one brand of slurry machine were immersed for 6 months in fungicide solutions or slurries of the same concentration used in seed-treating machines. The fungicides were Agrox (6.7 per cent phenylmercuriurea); Anticarie (40 per cent hexachlorobenzene); Ceresan M (7.7 per cent *N*-(ethylmercuri)-*p*-toluenesulfonanilide); MEMA (11.4 per cent 2-methoxyethylmercury acetate); Panogen 15 (2.2 per cent cyano(methylmercuri) guanidine); Velsicol Emmi (10.34 per cent 1,4,5,6,7,7-hexachloro-*N*-(ethylmercuri) bicyclo[2.2.1]hept-5-ene-2,3-dicarboximide). Liquid mercury formulations were more corrosive than mercurials formulated as wettable powders. All liquid preparations were equally corrosive on galvanized metal but only 2, MEMA and Velsicol Emmi, were corrosive to painted metal. Agrox and Ceresan M were less corrosive on the galvanized strips than were other mercurials. The Anticarie slurry, like water, was only mildly corrosive.

The mode of action of hexachlorobenzene as a seed treatment to protect against soil-borne fungi that cause common bunt of wheat. PURDY, LAURENCE H. Wheat seed treated with 1 oz. per bushel of 40 per cent hexachlorobenzene (HCB) is afforded good but incomplete protection against infection of the seedlings by soil-borne spores of *Tilletia caries* and *T. foetida*. Because of its low vapor pressure, HCB vaporizes slowly by sublimation. Vapor from 10 mg of HCB prevents spore germination on water agar but is not effective against seed-borne dry spores. When treated seed is planted in infested soil, the HCB vapor produces a zone around the germinating seed that is free of the smut fungi. Presumably, this zone enlarges so that the seedling in its early development, remains within it. With continued growth, the seedling passes through this zone into soil not yet affected by the HCB vapor and there becomes infected. This may account for the small amounts of smut that develop from soil-borne spores despite HCB seed treatment.

Physiological breakdown of chlorophyll in the Gesneriaceae. RAABE, ROBERT D. To test the environmental factors leading to the loss of green color and to ring spotting in members of the Gesneriaceae (including species belonging to the genera *Achimenes, Chirita, Episcia, Gloxinia, Rechsteineria, Saintpaulia, Sinningia, Smithiantha,* and *Tydaea*), these plants were grown on a greenhouse bench under a black cloth enclosure. Light was supplied by fluorescent fixtures. The pots were embedded in about 4 in. of peat moss and were watered by means of a plastic sprinkler hose buried in the moss. Water at different temperatures was used to induce the injury. In addition, excised leaves from plants grown in this enclosure were used in controlled light and temperature chambers. Factors found important in the breakdown of the chlorophyll were light intensity, temperature differences between the leaf and the water used, length of time of exposure to the cold water, and wave lengths of light used. In addition, natural pigment variations from 1 variety to another within a species were found to be important, the more highly pigmented varieties being more resistant to the injury.

A mosaic virus of Ranunculus and its electron microscopy. RAABE, ROBERT D., AND A. HERBERT GOLD. A virus that causes mosaic of Ranunculus (*Ranunculus asiasticus* L.) has been found to be readily transmissible by mechanical means. Other than Ranunculus, symptoms have been produced only on Pinto bean when inoculated with the Ranunculus mosaic virus. In Ranunculus, typical mosaic symptoms appear 10–12 days after inoculation and are more pronounced when the plants are grown under cool and semi-shady conditions. Virus-infected plants grown under warm and sunny conditions, however, fail to flower normally, the leaves dry up, and the plants become dormant sooner than do virus-free plants. Extracts from infected leaves, when viewed with the electron microscope, contained rod-shaped particles. Such particles were not present in extracts from virus-free plants.

Correlation between pea root rot in commercial fields with greenhouse determinations of soil infestation. REILING, T. P., AND T. H. KING. Greenhouse determinations for pea root rot were made from 49 fields in 1955 and 45 fields in 1956 in Minnesota and Wisconsin and correlated with the root rot that developed in these sampled fields when they were planted to commercial peas. Highly significant correlation coefficients of 0.709 for 1955 and 0.458 for 1956 were obtained. Determinations of root rot in the greenhouse were made from peas planted in soil taken at random from fields to be planted to commercial peas and harvested at full bloom. Results also indicate that yield is inversely related to the amount of root rot present in the field. As far as root rot is concerned, a reliable method has been developed for selecting fields suitable for growing canning peas.

New Hampshire Surecrop—A new tomato variety highly resistant to late blight and moderately resistant to early blight. RICH, A. E., AND A. F. YEAGER. A new tomato variety that has shown a high degree of resistance to *Phytophthora infestans* and moderate resistance to *Alternaria solani* has been developed at the New Hampshire Agricultural Experiment Station and named New Hampshire Surecrop. It is an early variety and produces a good crop of medium sized fruits. The original source of resistance to *P. infestans* was a cherry tomato (Rockefeller Foundation Selection X907W), identified as *Lycopersicum esculentum* var. *cerasifolium*, possessing a dominant gene for resistance. The new variety is highly resistant to tomato race 0 of *P. infestans*, and to the common field strains of the organism, but fruits are occasionally infected during severe epiphytotics. In greenhouse tests, it was much more resistant to *A. solani* than was New Hampshire Victor, one of its parents, and compared favorably with accessions selected for resistance to the early blight pathogen. It also showed appreciably more resistance to early blight in field tests than did New Hampshire Victor and Marglobe and outyielded both of these varieties in yield trials conducted in 1955, when late blight was not a factor.

Sporulation initiators for mycelial strain of Monilinia fructicola. RICH, SAUL, AND JAMES G. HORSFALL. A search was made for naturally occurring compounds that could initiate sporulation in a normally nonsporulating strain of *Monilinia fructicola*. Yeast extract and histidine initiated sporulation, whereas threonine, lysine, valine, glutamic acid, glycine, nicotinamide, theobromine, hypoxanthine, guanine, allantoin, 6-methyl thiouracil, and urea did not. Another experiment tested the possibility that histidine initiated sporulation by acting as a chelator to carry in metallic ions. Besides histidine, only its analogs, histamine and imidazole, initiated sporulation. Of the metallic ions tested in excess, only zinc initiated sporulation; ferric, cobaltous, cupric, manganous, or magnesium ions did not. Sporulation was not initiated by the following chelators: 8-quinolinol, dithizone, quinaldic acid, α, α -dipyridyl, ethylenediaminetetraacetic acid, cystine, and cysteine. Spectrographic analysis showed no difference between the zinc content of high-histidine mycelium and that of the

controls. Because of this, and because no other chelators initiated sporulation, it does not seem likely that histidine acts by carrying metals into the mycelium. It may well be that the mycelial strain of *M. fructicola* does not sporulate because of a block in its histidine metabolism.

A small electrical hygrometer for microclimatic measurements. ROGERS, MARLIN N. A small-sized modification of the Dunmore electrical hygrometer (1/12 × ½ in.) was constructed and used to make direct relative humidity measurements as near the leaf surface as 0.75 mm. This remote-reading instrument removes almost negligible quantities of moisture from the air during use and may be used in still air or in small enclosed spaces. It reaches equilibrium with its environment within 1–3 minutes; with suitable indicating devices, it measures relative humidity reliably to an accuracy of 1 per cent or better. By means of this instrument, it was found that relative humidity values near leaves increased when leaf temperatures were depressed below air temperature. Infection of snapdragons by *Puccinia antirrhini* and of tomato plants by *Cladosporium fulvum* occurred at 85 per cent ambient humidity when leaf temperatures were below air temperatures.

Some effects of moisture and of leaf-temperature depression on the development of powdery mildew of roses. ROGERS, MARLIN N. Different relative humidities at the surface of leaves were obtained by exposing plants to controlled conditions within a specially constructed chamber having 1 refrigerated wall. Leaves lost heat by radiation to this cold surface more rapidly than did the air adjacent to them. Consequently, leaf temperatures below air temperatures occurred. Leaf relative humidity values varying from 55 to 100 per cent resulted in no significant differences in the severity of powdery mildew (caused by *Sphaerotheca pannosa* var. *rosae*) until condensation on the leaves occurred. Repeated cycles of high (90 per cent) and low (30 per cent) ambient relative humidity following inoculation likewise had no significant effect on disease severity. Intermittent mist applied immediately following inoculation inhibited mildew development, particularly spore germination. The degree of inhibition was related to the length of exposure. Mist applied following infection caused no immediate reduction in mycelial growth or in sporulation; however, if the treatment was continued for 5–6 days, collapse of the conidia, both those detached and those remaining attached in chains, was noted.

Effect of temperature on the life cycle of stubby-root nematodes. ROHDE, R. A., AND W. R. JENKINS. Chesapeake tomato seedlings grown in 3-oz. glass vials were each inoculated with 5 gravid females of *Trichodorus* sp., and the vials were then suspended in water baths maintained at 20°, 22°, 30°, and 35°C. At intervals of 24–48 hours, 2 vials were removed from each water bath, nematodes were recovered from the soil, and measurements of each specimen were taken from sketches made with a Leitz drawing apparatus. Recovery of gravid females in excess of the number originally added was considered an indication of completion of a life cycle. This process required 16–17 days at 30°, whereas a life cycle was finished in 21–22 days at 22°. At 35°, larvae were not recovered, and at 20° no increase in number of gravid females was observed. When over-all length was plotted against beta value (total length divided by length of esophagus) for all nematodes recovered at 22° and 30°, 4 distinct groups were noted in each case. Each group having roughly the same length and beta value was considered as a free-living stage in the life cycle. All stages found were larger at the lower temperature. Temperature evidently has an effect not only on the length of the life cycle, but also on the relative sizes of both larvae and adults.

The recovery from susceptible oats of the toxin produced by Helminthosporium victoriae. ROMANKO, R. R. Previous work has shown that filtrates from *H. victoriae* contain a toxic substance, victorin, which induces the same symptoms and shows the same specificity as the pathogen itself. To study the action of this toxin, cuttings of resistant and susceptible oat varieties were placed in buffered solutions containing 10 units of victorin per ml. Cuttings of both types placed in buffered solution alone provided controls. Since extracts from controls possessed a low-level, nonspecific toxicity, only specific toxicity above this level was considered to indicate the recovery of absorbed victorin. After 12 hours, susceptible cuttings in victorin solutions were noticeably wilted, whereas resistant cuttings in victorin and the controls not exposed to the toxin were unaffected. The cuttings were then extracted with water and the extracts diluted and assayed for toxicity. Little or no victorin was recovered from resistant plants, whereas victorin in concentrations up to 2.5 units/ml was readily recovered from susceptible plants. Failure to recover victorin from exposed resistant plants suggested that the toxin might be inactivated in such plants. Tests involving mixtures of plant extracts and victorin, however, have as yet failed to provide evidence of such inactivation.

Relationship of reaction type in crown rust to the rate of carbohydrate metabolism in oats. ROSEN, H. R., AND L. F. BAILEY. In an attempt to determine why certain oat selections present an immune reaction to race 203 of the crown rust fungus at temperatures of 70°F or below and a susceptible reaction at higher temperatures, it was found that the immune reaction could be broken at temperatures favorable for such reaction. It was broken by the addition of CO_2 to the atmosphere in which the plants were grown and by the addition of a sucrose solution applied as a foliar spray. The optimum concentration of CO_2 necessary to break resistance appears to be 0.15 per cent when applied immediately after inoculation, and the optimum length of time appears to be 48 hours. Optimums for sucrose applications have not been determined. Although these findings do not preclude the possibility of other factors playing a role in host reaction to crown rust, the evidence appears substantial that the rate of carbohydrate metabolism of the host and the availability of carbohydrate metabolites to permit adequate growth of the parasite play an important and perhaps deciding part in host reaction.

Free amino acids and amides in healthy and Verticillium-infected peppermint and chrysanthemum plants. ROSS, J. P. After being inoculated with a spore suspension of *Verticillium albo-atrum*, cuttings of peppermint (*Mentha piperita* var. Mitcham) and chrysanthemum (*Chrysanthemum morifolium* var. Mary L. Hall) were rooted and grown in the greenhouse. The free amino acids in leaf and stem extracts of these plants and of healthy checks were determined by quantitative paper-partition chromatography. In chrysanthemum, infected leaf tissue contained much more proline than did healthy, whereas infected stems contained markedly less amide N than did healthy stems. In infected mint stems there was a shift from glutamine to asparagine with no large change in total amide N. The total soluble amino acid N of infected mint stems was 3 times that of healthy stems 13 days after inoculation. Pipecolic acid was detected in the stems of infected mint 10 days after inoculation and in leaf tissue 7 days later; it was never detected in healthy mint plants. Lysine, but not pipecolic acid, was found in mycelium of *V. albo-atrum* cultured in Coon's medium. Pipecolic acid was detected in healthy mint cuttings into which lysine was introduced. This suggests that lysine produced by the fungus may be transformed into pipecolic acid by the metabolic activities of the host plant.

A comparative study of fungitoxicity and phytotoxicity in an homologous series of N-n-alkylethylenethioureas. ROSS, R. G., AND R. A. LUDWIG. A comparative study of fungitoxicity and phytotoxicity was made with an homo-

logous series of *N*-*n*-alkylethylenethioureas ranging from the ethyl to the dodecyl homologue. Fungitoxicity increases up to the octyl homologues, whereas apparent phytotoxicity reaches a maximum at the amyl homologue. Toxicity to plants depends on the ability of the chemical to reach the protoplasts. When the protoplasts are exposed to the chemicals, phytotoxicity increases with chain length up to at least the octyl homologue. Studies on the uptake of the compounds from aqueous solution by potato tissue and by spores of *Sclerotinia fructicola* show that a distribution equilibrium exists between the tissue or spores and the external solution. The affinity for the biophase increases with increasing length of side chain. The differential toxicity of the homologues results from the partitioning of the chemical between the 2 phases.

Effect of dew evaporation rates on infection of wheat by Puccinia graminis var. tritici. ROWELL, J. B., C. R. OLIEN, AND ROY D. WILCOXSON. The rate at which wet leaf surfaces were dried after postinoculation dew periods affected the infection of wheat seedlings inoculated with urediospores of the wheat stem rust fungus. Little Club wheat seedlings were inoculated in a spray chamber with controlled numbers of fresh urediospores (race 15B) carried in a mineral oil mixture and then were placed in a constant-temperature (70°F) dew chamber. Slow drying of plant surfaces for 3 hours at 65°F and near saturated relative humidity (r.h.) after a 4-hour dew period resulted in approximately 5 times as much infection as did rapid drying at 65°F and 50 per cent r.h. after an 8-hour dew period. Infection increased with the length of the drying period up to 3–4 hours following a dew period of either 4 or 8 hours. Microscopic examination of samples of peeled epidermis demonstrated that spore germination was constant after a 4-hour dew period (90+ per cent of spores counted) and appressorium formation was constant after an 8-hour dew period (50+ per cent). Vesicle formation was rare before the end of the drying period, and most were formed 8–48 hours after the dew period. Slow and fast drying apparently affected appressoria; slow drying after 8 hours in the dew chamber resulted in 5–10 times more vesicles and infections than did fast drying.

A physiologic form of Plasmopara viticola found for the first time. SANTILLI, VINCENT. The grape downy mildew fungus was found to occur in California only on the wild grape (*Vitis californica* Benth.). No authentic record of its existence on the cultivated grape (*V. vinifera* L.) was found. No verifiable record of its occurrence in Canada or the United States west of the Rocky Mountains, except for California, was located. By means of artificial inoculations and by comparison with *P. viticola* from the eastern United States, it was discovered that the California fungus was a physiologic strain of *P. viticola*, the first so characterized, and was incapable of completing its life cycle on *V. vinifera* and other species of *Vitis* that serve as hosts of this fungus outside California. *V. californica*, *V. girdiana* Munson, *V. arizonica* Engel., and *V. treleasei* Munson were the only species found to be susceptible to the California strain. These 4 species are extremely susceptible to the eastern form of the fungus. Inoculation of leaves of *V. californica* with the eastern fungus resulted in infection of a greater percentage of the leaves, in production of earlier and more extensive symptoms, and in earlier and more profuse sporulation than did similar inoculations with the California fungus. These differences in virulence were greater on the older than on the younger leaves.

Grafting experiments with Fusarium wilt resistant and susceptible tomato plants. SCHEFFER, R. P. Susceptible (var. Bonny Best) and highly resistant (var. Jefferson) tomato plants were approach grafted in pairs. When graft unions were firm, the top of one plant and the bottom of the other in each pair were severed, and bud cell suspensions of *Fusarium oxysporum* f. *lycopersici* were introduced through spurs of scions. Combinations used were 1) susceptible scion on resistant stock, 2) susceptible scion on susceptible stock, 3) resistant scion on susceptible stock, and 4) resistant scion on resistant stock. Typical symptoms developed in susceptible tops of combinations 1 and 2. Plants with resistant tops did not show symptoms, regardless of the root type. Top leaves of several plants of combination 3 flagged without showing typical symptoms of the disease. In these cases, the fungus was found to have invaded and caused vascular dysfunction in the susceptible stocks. These data are evidence against the theory that susceptibility depends on root-produced factors (i.e. that resistance results from lack of root-produced factors). Results also confirm earlier conclusions that resistance is present in stems and is not inherently different from the resistance expressed in roots.

Influence of temperature and light upon substomatal vesicle formation in Puccinia graminis var. tritici. SCHMITT, C. G., AND JOHN M. STALEY. Substomatal vesicle formation in *Puccinia graminis* var. *tritici* (Eriks. & E. Henn.) Guyot was favored by growing the host in light (in excess of 500 foot-candles) from seedling emergence to inoculation. Increases in vesicle formation were obtained by placing inoculated plants in the light only during the last few hours of the dew period. A temperature of 85°F is near optimum, 95°F is near maximum, and 55°F is near minimum for vesicle formation either in light or in darkness. To determine the degree of vesicle formation, the upper surface of the leaf was scored with a razor blade at right angles to the axis. Then a slit was made with the blade between mesophyll and lower epidermis. This made it possible to grasp the upper epidermis and adhering mesophyll with the thumbnail of one hand while the epidermis was stripped back with the other hand and mounted exterior down in lactophenol containing analine blue and acid fuchsin.

Injection-infestation technique for studying root rot pathogens. SCHMITTHENNER, A. F., AND L. E. WILLIAMS. A method for rapidly screening the root-rotting potential of a large number of soil fungus isolates was developed. Seven-day-old corn, wheat, oat, and soybean plants and 10-day-old alfalfa and red clover plants (beyond the damping-off stage) were inoculated. Plants from sterilized seed were grown in autoclaved quartz sand in 16-oz. paper cups and watered with complete mineral solutions. With sand culture, roots could be easily removed and mineral nutrition controlled. A cup was infested by injection with 50 ml of 2- to 3-day-old shake cultures of fungi in liquid medium containing yeast extract (0.15 per cent), glucose (0.3 per cent), and phosphate (0.075 per cent). Injection was with a hypodermic syringe attached to a 3-in. 12-gauge needle having 2 side openings and a closed end. Most young shake cultures could be used without grinding of mycelium and were desirable because phytotoxic staling products were not produced. Needle inoculations were faster, eliminated abnormal wounding of plants, and resulted in as severe disease as did transplanting into sand-inoculum mixtures. This method was satisfactory for demontrating pathogenicity of certain isolates of species of *Fusarium*, *Pythium*, *Rhizoctonia*, and *Phytophthora*.

Distribution of southern bean mosaic virus and symptoms as affected by high temperature. SCHNEIDER, I. R., AND J. F. WORLEY. Primary detached leaves of bean of several varieties inoculated with southern bean mosaic virus were maintained on agar for 6 days. At 20°–22°C and with a 12-hour light period daily, local lesions formed. When comparable leaves were kept at 32° for the first 24 hours after inoculation, necrosis of large and small veins occurred in addition to the local lesions. With longer exposure (48 hours) to 32°, necrosis was largely restricted to the veins and veinlets and there were few local lesions. After 24 and 48 hours at 32°, the leaves were kept for 5 and 4 days, respectively, at 20°–22°, the temperature that favored local-

lesion formation. Relative proportions of veinlet necrosis and local lesions depended on how long after inoculation the leaf was first subjected to high temperature and on the duration of the exposure. Infectious southern bean mosaic virus was detected in ground samples of leaves with necrotic veinlets but no local lesions. Uniform disks with 1 lesion per disk or with necrotic veinlets were cut from leaves. Much more infectious virus per unit leaf area was detected in the necrotic-veinlet samples than in the local-lesion samples.

Radiation-induced mutations in race 1 of the flax rust fungus. SCHWINGHAMER, E. A. A spore color variant and a high frequency of mutations from avirulence to virulence were obtained from irradiated urediospores of *Melampsora lini*, race 1. Spores were exposed to ultraviolet, X-ray, and thermal neutron radiation at the estimated LD_{50} values determined from dosage-survival studies. These values were 12.3×10^5 ergs/cm^2, 50 Kr. and 5.4×10^{13} N_{th}/cm^2, respectively. The white-spored culture, representing a loss of orange pigment, was pathogenically identical with the original race 1. The total number of pathogenic mutants exceeded 4300. Genetic changes from the heterozygous to the homozygous recessive condition were detected by the appearance of large uredia on the highly resistant varieties Dakota and Koto. When the pustule count on the susceptible variety Bison was used as a measure of survival in the irradiated spore population, the mutation frequency with X-rays, based on preliminary data, was calculated at 0.82 per cent (382 in 46,450) for the "Dakota" rust locus and 0.12 per cent (91 in 73,220) for the "Koto" locus. The yields of mutations induced at the same level of lethality by X-rays and by thermal neutrons did not differ appreciably, but exceeded the number induced by ultraviolet by approximately 9:1. In a pathogenicity test, 15 mutants isolated from Dakota differed from race 1 only in their ability to attack Dakota.

A "tissue transplant" technique for obtaining abundant sporulation of races of Puccinia graminis var. tritici occurring on resistant varieties. SHARP, E. L., AND R. G. EMGE. A method has been developed for transplanting leaf tissue of resistant varieties infected with *Puccinia graminis* var. *tritici* (Eriks. & E. Henn.) Guyot into a healthy susceptible leaf. The method consists essentially of stripping back the lower epidermis of a healthy leaf and placing the desired transplant containing similarly exposed infected tissue so that its mesophyll is adjacent to the exposed mesophyll of the healthy leaf. The epidermis of the healthy leaf is then replaced over the transplant tissue. Microscopic examination after 2 days showed the mycelium to be growing from the transplant into the healthy tissue; within 5 days, a lesion could be seen macroscopically. Abundant sporulation occurred after 7 days. The technique should be useful in rust identification and perhaps in studies on the nature of parasitism.

Influence of temperature and light on the infection process of Puccinia graminis var. tritici. SHARP, E. L., J. M. STALEY, C. G. SCHMITT, AND C. H. KINGSOLVER. In wheat infected by *Puccinia graminis* var. *tritici*, the infection process, including all stages from germination through establishment within the host, can be divided into 2 distinct phases on the basis of the influence of temperature and light. Germination and appressorium formation progressed equally well at temperatures of 60–75°F and at light intensities of less than 300 foot-candles. Postappressorium development was best at 85°F in light intensities exceeding 500 foot-candles. Under a dew condition, temperature of 85° for 1 hour after one of 60° for 9 hours resulted in 10 times the amount of infection that occurred after 10 hours at 60°. Up to 10-fold increases in pustule numbers were obtained by orienting leaf surfaces of inoculated plants so as to receive maximal light during the last 2 hours of the dew period at a temperature of 80°. This emphasizes the inadequacy of using average temperatures for estimating infection in the field.

Stem rot disease of Irish potato. SHEALY, ROBERT D. In 1955, a stem rot disease of Irish potato was severe in Ohio. Apparently, aboveground plant parts are invaded by the pathogen, but decay may extend into the roots. A bacterium that was isolated repeatedly, in 1955 and 1956, from diseased tissue incited the disease on plants in the field and greenhouse. Tubers were planted in soil collected in early March, 1956, from fields in which the disease had been severe in 1955. Symptoms of the disease developed on plants growing in this soil in the greenhouse. The morphological and cultural characteristics of the pathogen are similar to those of non-gas-forming species of several plant pathogens that cause soft rots of many vegetables, yet the pathogen does not fit the description of any species. No resistant potato varieties have been found.

Response of roses to field fumigation for lesion nematode. SHER, S. A. *Pratylenchus vulnus*, the lesion nematode, is widespread in southern California on poorly growing roses. A field heavily infested with this nematode was treated prior to planting with the following: chloropicrin (trichloronitromethane) at 33 gal./acre, Vapam (*N*-methyl dithiocarbamate) at 40 gal./acre, D-D (1,3-dichloropropene; 1,2-dichloropropane) at 40 gal./acre and Dowfume W-85 (1,2-dibromoethane) at 8 gal./acre. Chloropicrin was applied with a hand-injector gun and D-D and Dowfume W-85 with commercial chisel applicator. Vapam was applied as a drench and also chiseled into the soil. Nine months after planting, all the treatments showed a visible response over the checks. The average dry weight in grams of the tops of 10 plants from each treatment and from the checks were as follows: chloropicrin, 82; Dowfume W-85, 71; D-D, 70; Vapam injection, 59; Vapam drench, 39; and check, 30. Roots were correspondingly larger and cleaner appearing than those of the checks. The increase in plant growth was correlated with a decrease in number of lesion nematodes around the roots.

Panicum mosaic, a new virus disease of Panicum virgatum and related grasses. SILL, W. H., JR. A new virus disease of *Panicum vergatum* L., switchgrass, was seen first in 1953. The host range of the causal virus is distinctly different from that of other known grass viruses. Typical symptoms consisted of a yellow-green leaf mosaic and mottle, diffuse on some plants and definite on others. Some plants were chlorotic and stunted. The disease has persisted 3 years in individual plants in both field and greenhouse. Only a small percentage of plants in the field have been diseased, but potential forage losses appear to be heavy. Attempts to transmit the virus by manual inoculation methods to varieties of wheat, oats, corn, sorghum, rye, and barley failed, but attempts were successful with 10 selections of *P. virgatum*, 4 other species of *Panicum*, *Digitaria sanguinalis* (L.) Scop., *Setaria italica* (L.) Beauv., and *Echinochloa crusgalli* (L.) Beauv. (a symptomless carrier). Many grasses, 1 sedge, and 5 dicotyledonous species were immune. Incubation periods in *D. sanguinalis* varied from 7 to 15 days during warm weather and increased at lower temperatures. In 3 trials, the apple-grain aphid, *Rhopalosiphum prunifoliae* (Fitch.), did not transmit the virus. Successful cross inoculations were made between all susceptible species. Several selections of *P. virgatum* were resistant.

The development of Puccinia graminis var. tritici on detached leaves of wheat as influenced by nutrients and metabolite antagonists. SILVERMAN, WILLIAM B. Uredia of race 15B of *Puccinia graminis* Pers. var. *tritici* Eriks. & E. Henn. developing on detached leaves of Little Club wheat were provided various nutrient solutions expected to affect

mycelial growth and sporulation. All uredia of the wheat stem rust fungus were compared with 3 standards: small, intermediate, and large uredia developing on leaves maintained in distilled water, 0.3 M mannose, and 0.3 M sucrose, respectively. Various metabolite antagonists, amino acids, and vitamins had no effect. Only the hexoses, glucose and fructose, and oligosaccharides composed of glucose and/or fructose moieties supported large uredia. Generally more than 50 per cent of spores from intermediate to large uredia germinated, but less than 50 per cent of those from small to intermediate uredia germinated. Sugar alcohols, especially sorbitol and mannitol, supplied to detached leaves caused blackening of uredia. Sorbitol also caused blackening when sprayed on intact infected seedlings. Blackened uredia contained discolored, misshapen, nonviable spores; hyphae of the fungus and the walls of host cells in the region of spore formation were discolored. Nevertheless, some mycelium resumed normal sporulation if the blackening agent was withheld and a sugar favoring sporulation was substituted, or in the case of intact leaves, if the sugar alcohol spray was discontinued.

The use of protective fungicides to control crown rust of oats. SIMONS, M. D. In 1952 and 1953, nabam + $ZnSO_4$ and certain other protective fungicides applied 3 times during the season for control of crown rust (caused by *Puccinia coronata* Cda. var. *avenae* Fraser & Led.) on artificially inoculated oats resulted in yields and test weights significantly superior to those of the untreated checks. In 1954 and 1955, the first treatment was timed to coincide with the appearance of crown rust in moderate trace amounts; 2 others followed at intervals of several days. Some plots received nabam + $ZnSO_4$ on only the first date, others on only the second, others on only the third, and still others on all possible combinations of the 3 dates. Only those plots treated on the first date, regardless of whether they received 0, 1, or 2 additional treatments, were significantly superior to the check in both yield and test weight. Sulfur dust applied similarly did not increase yields. In 1956, field observations of treated plots and measurements of leaf area at the times of treatment confirmed the importance of correctly timing the first application of nabam + $ZnSO_4$.

Virulence of single-basidiospore isolates of Pellicularia filamentosa as affected by preculture on vitamin-amended media. SIMS, ASA C., JR. Three selected single-basidiospore isolates of *Pellicularia filamentosa* differed in rate of growth and amount of mycelium on a thiamine-amended basal medium but not on biotin- and inositol-amended media. The media on which one of the isolates was increased had an effect on its subsequent virulence. This isolate was increased on vitamin-amended basal media maintained at 20° and 30°C. Biotin and thiamine combined in the medium on which the isolate was increased previous to inoculation resulted in a decrease in virulence as measured by number of cotton seedlings killed. Inconclusive evidence was obtained that biotin-, thiamine-, and inositol-amended media resulted in decreased virulence. Two single-basidiospore isolates, progeny of the single-basidiospore parent isolate, were reisolated from diseased cotton seedlings and found to have decreased in virulence following increase on the same vitamin-amended media previous to inoculation. Dry weights of inoculum differed within isolates after growth on different media.

Biophysical studies of the wild cucumber mosaic virus. SINCLAIR, J. B., P. H. GEIL, AND PAUL KAESBERG. Partially purified preparations of the virus examined in a Svedberg oil turbine centrifuge revealed 2 schlieren peaks. Whole virus layered on sucrose density-gradient columns and then centrifuged produced 2 layers: an upper layer of top component and a lower layer of bottom component. Top component was not infectious; bottom component was infectious. Ultraviolet absorption tests gave typical nucleic acid absorption for bottom component and whole virus. Top component contained no nucleic acid. The isoelectric point was pH 6.6. Sedimentation constants were $S_{20,w}$ = 59.2 S (top) and $S_{20,w}$ = 115.5 S (bottom). The diffusion was $D_{20,w} = 1.1 \times 10^{-7}$ cm^2/sec. X-ray scattering tests showed bottom component with a diameter of 286 A and top component with a diameter approximately 289 A and a central core 0.7 times the particle diameter. Examination of air- and frozen-dried preparations in an electron microscope indicated that the particles of bottom component have a diameter between 250–300 A and are polyhedrous in shape. Top component preparations were not consistent.

Purification and properties of hydrangea ringspot virus. SISLER, HUGH D., SING CHEN CHANG, REGINALD L. REAGAN, AND PHILIP BRIERLEY. The virus causing hydrangea ringspot was purified from leaves of *Hydrangea macrophylla* (Thumb.) DC. by combination of ammonium sulfate precipitation and differential centrifugation. Infectious preparations gave ultraviolet absorption maxima between 260 and 265 mμ. The infectivity titer, optical density at the absorption maximum, and the protein concentration of infectious preparations were correlated. The purified preparations consisted of 2 electrophoretic components. The fast-moving fraction had an electrophoretic mobility of -3.9×10^{-5}cm^2/volt/sec., contained rod-shaped particles, and was infectious; the slow-moving component had a mobility between -1.7 and -2.2×10^{-5}cm^2/volt/sec., did not contain rod-shaped particles, and was not infectious. A mean particle width of 16.3 mμ and particle lengths of 44 mμ and greater were determined from electron micrographs. The particles were aggregated in an end-to-end arrangement into flexible filaments. Preparations containing approximately 1 per cent protein were spontaneously birefringent, whereas more dilute preparations exhibited flow birefringence.

Factors influencing infection of apple fruits by Botryosphaeria ribis. SITTERLY, W. R., E. B. WILLIAMS, AND J. R. SHAY. Symptom expression on apple fruits by *Botryosphaeria ribis* varies markedly with maturity of fruits. Rotting is arrested or progresses very slowly in immature fruits but spreads rapidly as the fruits ripen. Growth tests of the organism in culture were made at the pH levels and concentrations of different organic compounds present in immature and mature fruits. Tyrosine, asparagine, starch, sucrose, and fructose stimulated growth at both pH levels. Compounds that inhibited growth or were not utilized included thiamine, inositol, cellulose, lactic acid, and oxalic acid at the pH level of immature fruit. Intact fruits injected through spur-leaf petioles with sucrose, fructose, and tyrosine showed positive infection nearly 3 weeks earlier than did the controls. Compounds that inhibited growth or were not utilized in culture failed to protect injected fruits artificially inoculated when almost mature. Intact fruits treated with maleic hydrazide to inhibit respiration could be successfully inoculated 10 days before the controls. Immature fruits picked and then treated with ethylene to stimulate respiration became infected, following inoculation, 35 days before the controls did.

Temperature and humidity relationships in securing infection of barley with Rhynchosporium secalis. SKOROPAD, W. P. Infection of barley leaves with *R. secalis* is initiated by conidia. The fungus sporulates abundantly, either from leaves floated on water for 48 hours at 10°C or in young cultures on 1 per cent malt-yeast agar at 15–20°C. Conidia from either of the above sources were mixed with soft agar and smeared on barley leaves. Following inoculation, the plants are covered with a polythene bag containing air saturated with moisture. Lesions appeared most rapidly (11 days) and the leaves were attacked most virulently when inoculated plants were held in saturated air at 15°–18°C for 48 hours and then moved to a greenhouse at about 24°. Incubation for 48 hours at lower temperatures

(6°–14°) also favored fairly rapid development of lesions (14–18 days), provided that high temperatures (24°C) prevailed subsequently. Lesions appeared very weakly and slowly or not at all when inoculated plants were held at 6–12°C or above 24° following inoculation.

Control of current-season infection of peach by Xanthomonas pruni in Arkansas. SLACK, D. A., AND M. L. HAMBLEN. In past years at Nashville, sprays of 6–8–100 zinc Bordeaux and of zinc oxysulphate (4 lb./100 gal.) significantly protected against fruit infection of Elberta peach by *Xanthomonas pruni;* however, foliage infection and defoliation were not affected. In 1955, sprays containing streptomycin partially controlled foliage infection. The average percentage foliage infection of sprayed Elberta trees was as follows: 120 ppm terramycin, 27; 100 ppm streptomycin plus 10 ppm terramycin (as Agri-mycin 100, which is 15 per cent streptomycin plus 1.5 per cent terramycin), 15; zinc Bordeaux, 33; zineb (2 lb/100 gal.), 34; check, 31; and Agri-mycin applied only after rain periods exceeding 1 in. in 24 hours, 6. In 1956, foliage infection was 16, 17, and 13 per cent with Agri-mycin treatments of 25, 50, and 100 ppm (of active ingredients), respectively, as compared to 34, 30, and 39 per cent for 3 lb. Vancide Z-65 (65 per cent mixture of zinc dimethyldithiocarbamate and zinc derivative of 2 mercaptobenzothiazole) per 100 gal., zinc Bordeaux, and check, respectively. Fruit infection was approximately 12 per cent on trees sprayed with Agri-mycin as compared to 25, 21, and 27 per cent for Vancide Z-65, zinc Bordeaux, and check trees, respectively. Under severe bacterial spot conditions at Fayetteville in 1956, however, control was not effected by similar treatments.

Inhibition of Fusarium oxysporum f. lycopersici by a species of Micromonospora isolated from tomato. SMITH, GLENN E. An organism, tentatively identified as a species of *Micromonospora*, was isolated from an apparently healthy Bonny Best tomato plant previously inoculated with *F. oxysporum* f. *lycopersici*. A conidial and mycelial suspension of *Micromonospora* sp. was mixed with warm agar in Petri plates. *F. oxysporum* f. *lycopersici* was completely inhibited when transferred to this agar 1 day or more later. When added to potato-dextrose agar, a 50 per cent dilution of a crude filtrate of the *Micromonospora* sp. inhibited *F. oxysporum* f. *lycopersici*. *Micromonospora* sp. was reisolated from about 20 per cent of apparently healthy tomato plants inoculated with this organism. Tomato plants growing for various periods in solution cultures of *Micromonospora* sp. before inoculation with *F. oxysporum* f. *lycopersici* had a Wellman rating for Fusarium wilt of 2.13 compared to 5.75 for untreated plants. Results were similar when the tomato plants grew in various concentrations of Micromonospora filtrate before inoculation with *F. oxysporum* f. *lycopersici*. When the Micromonospora filtrate was used, the average Wellman rating for the filtrate treated plants was 2.56 compared to 7.1 for the untreated plants.

Oospore formation in Phytophthora infestans. SMOOT, J. J., F. J. GOUGH, AND M. E. GALLEGLY. Oospores were consistently formed in abundance when any 1 of 3 isolates of *P. infestans* from Mexico was paired with any of more than 100 isolates from the British Isles, Western Europe, Africa, and North America. A fourth isolate from Mexico formed oospores only when paired with the other 3 Mexican isolates. All isolates were pure cultures of *P. infestans* pathogenic to potato. There was no correlation between the physiologic race and the mating reaction. Oospores formed between the 2 cultures soon after the juncture of the 2 mycelia and later involved a much wider area throughout a 3-mm layer of medium. As many as 250 oospores were observed in a single focal plane of a 1.5-mm-diameter microscope field. This is in contrast to the low numbers occasionally formed with single cultures or with intragroup pairings. Paired cultures formed oospores in liquid, agar, or gelatin media fortified with extracts of frozen lima beans, dried soybeans, or other natural materials. Oospores were formed also in the leaves of 16 varieties of potato and 1 variety of tomato following paired inoculations where the variety was susceptible to both parent strains. Mature oospores varied in diameter from 24 to 56 μ and in color from pale yellow to dark brown, depending upon the medium.

A Sclerotinia sp. (Imp. Sclerotium) with limited antifungal activity. SNYDER, W. C., AND H. N. HANSEN. A widespread *Sclerotium* sp. has been isolated frequently from dead or dying underground stems and roots of cereals, beans, sweetpotatoes, morning glory, pines, etc. Attempts to infect healthy plants of these hosts have been unsuccessful. The fungus appears to be neither parasitic nor pathogenic; however, it does seem to have interesting biologic properties in that it shows competitive or antagonistic action towards certain plant pathogens and rapidly invades sterilized soil. Its identity with Sclerotinia has been determined by mating an Italian isolate with one from California on gas-sterilized (propylene oxide treated) seeds of sorghum imbedded in water agar, with subsequent incubation in pure culture out of doors. Apothecia were produced. Single ascospore cultures have shown that the fungus is highly variable, heterothallic, hermaphroditic, and self-sterile, with 2 compatibility groups. It produces spermatia but no conidia.

Detection of Heterodera glycines in North Carolina. SPEARS, J. F., S. C. BALCOMBE, AND G. HEMERICK. Symptoms of soybean cyst nematode disease were visible on snapbean and soybean foliage 6 weeks after planting where cyst count prior to planting was from 5 to 200 cysts/lb. soil; at 1 cyst/lb., symptoms were observed on soybean 12 weeks after planting; at 1 cyst/10 lb. soil/acre, no symptoms were observed. Symptoms were conspicuous on diseased plants where relatively healthy soybean plants were growing rapidly, i.e. where other conditions were favorable for growth. In such fields, diseased plants were in elliptical areas, 1×2 to 10×20 yards across. Diseased plants were 7–10 in. high where surrounding healthy plants were 38–42 in. high. Diseased plants were yellow, with the chlorosis beginning distally on the foliage. Roots of diseased plants were small, dark, odorless, and had few or no nodules. Cysts were plainly visible on such roots. Over 100,000 acres of soybeans in eastern North Carolina were inspected for symptoms of this disease in 1956. Five infested properties were discovered, extending the limits of the known infested area 3 miles east, 3 west, and 7 north.

Numbers of nuclei in cells of vegetative structures of Alternaria solani. STALL, ROBERT E. The nuclear content in cells of vegetative structures of a sporulating strain of *Alternaria solani* (Ell. & Mart.) Jones & Grout was determined in order to gain an insight into the variability of the organism. Nuclei were stained best by Delafield's hematoxylin after the black cell-wall pigment was removed by a solution of 2 per cent hydrogen peroxide containing a trace of sodium hydroxide. Mycelial cells contained 1–9 nuclei. More nuclei were present in ultimate cells of hyphae than in penultimate cells. One to 4 nuclei were observed in conidiophore cells. Numbers of nuclei in the cells of mature conidia were variable. Cells toward the base of the conidia contained as many as 8 nuclei, whereas cells toward the beak contained 1 or 2. In general, cells having larger numbers of nuclei were larger in size. Conidial primordia contained 1–3 nuclei. Observations indicate that more than 1 nucleus often exist in conidia at the time of their initiation. Therefore, heterocaryotic conidia can arise from heterocaryotic mycelia. Well-defined pores were observed between cells of the conidia as well as between cells of the mycelia. These pores possibly could

permit the cell-to-cell migration of nuclei or other hereditable constituents.

Heterocaryotic variation in Alternaria solani. STALL, ROBERT E., AND LEONARD J. ALEXANDER. Heterocaryosis has been established cytologically as a possible mechanism of variation of *Alternaria solani* (Ell. & Mart.) Jones & Grout. When X-ray induced and other mutants were used as sources of heterocaryotic mycelia, attempts to isolate heterocaryons after anastomosis of strains failed, even though anastomoses occurred frequently. Cultures from hyphal tips isolated from germinated mycelial fragments from heterocaryotic cultures were either heterocaryotic or homocaryotic, an indication that segregation of different nuclear types occasionally takes place in the hyphae of heterocaryotic cultures that form homocaryotic hyphae. When a representative isolate of *A. solani* from tomato leaves was studied, cultures from germ-tube tips isolated from the same conidium differed only slightly in cultural characteristics. When the cultures were tested on 6 tomato hosts, significant differences in pathogenicity were noted. Cultural and pathogenic variation in successive vegetative generations of hyphal-tip cultures originating from certain germ-tube tips was not as great as that among the germ-tube tip cultures themselves. The variation of the wild isolate did not appear to be due to heterocaryosis, since segregation of cultural types was not encountered.

The isolation of citric and malonic acids, the tentative identification of other acids of the Krebs cycle, and the effect of these acids upon the respiration of uredospores of the leaf rust fungus of wheat. STAPLES, RICHARD C. Uredospores of the leaf rust fungus were extracted with ether by the method of Pucher and separated on an anion-exchange column according to the method of Palmer. The acids found in the eluate of the column were identified by comparison with the elution curve of a mixture of known acids and by paper chromatography. This study led to the tentative identification of succinic, malic, citric, malonic, fumaric, and aconitic acids. The most predominant fraction of the eluate, a mixture of citric and malonic acids, was further separated on a silica gel column by the method of Bulen, Varner, and Burrell. After recrystallization of the acids, the melting point, infrared spectrum, and carbon-hydrogen analysis of the crystals were determined. These data confirmed the identification of citric and malonic acid. The ratio of malonic to citric acid was about 1. Succinate added to the intact spores increased their rate of oxygen uptake when measurements were carried out in phosphate buffer at pH 7.0. This substrate-induced oxygen uptake was reduced to the blank level with the addition of an equivalent amount of malonate.

A new subrace of the oat stem rust fungus from barberry. STEWART, DONALD M., C. W. ROANE, W. Q. LOEGERING, AND B. J. ROBERTS. Telia of both *Puccinia graminis* var. *avenae* and *P. graminis* var. *tritici* were collected in 15 or more locations in southwestern Virginia and used to inoculate barberry bushes in an area isolated from grain fields. Varieties of oats and wheat susceptible to certain races, and others resistant to all known races in the United States, were planted near the barberries. Rust was observed to spread to the varieties, and uredia were collected from those varieties with large pustules. Many races and subraces were identified from the various collections, including a subrace of race 5 of *P. graminis* var. *avenae* from Saia oats, *Avena strigosa*. This subrace has been designated 5-US 1. On the standard differentials and 10 other supplemental oat varieties, infection types produced by this subrace were similar to those of field collections of race 5, but Saia was susceptible to 5-US 1 and resistant to other isolates of race 5 tested. Saia has been susceptible to some isolates of the stem rust fungus in South America but resistant or intermediate in reaction to all United States isolates until 5-US 1 was found. The occurrence of a factor for virulence on Saia in the United States is important, as an attempt is being made to incorporate the stem rust resistance of Saia into economic oat varieties of *Avena sativa*.

Control of loose smut of barley by water-soak and chemical methods. TANDON, I. N., AND E. D. HANSING. Effective control of brown loose smut of barley was obtained by soaking the seed at 75°F for 56 hours in 0.2 per cent Vancide 51 (30 per cent sodium dimethyldithiocarbamate and sodium derivative of 2-mercaptobenzothiazole), in 0.01 per cent Panogen 15 (2.2 per cent cyano (methylmercuri) guanidine), or in water. Control by these methods also was obtained at other temperatures and lengths of soaking combinations. Emergence and yield were adversely affected oftener by the water-soak treatment than by the corresponding Vancide or Panogen treatments. Spergon-SL (95 per cent chloranil) at 0.1 per cent affected emergence so seriously that it was unsuitable for practical use. Smut was not controlled at 32° and 48°F by increasing the soaking to 8 days. The quantity of water used in soaking the seed made no difference in the control of smut. The anaerobic treatment was superior to soaking in water; the effect on emergence of the former usually was not statistically significant. The most effective anaerobic treatment consisted of soaking the seed for 2 hours in water and then holding the soaked seed in an airtight container at 80°F for 48 hours.

A modified aceto-osmium staining method for demostration of nematodes in citrus root tissues. TARJAN, A. C., AND H. W. FORD. Difficulties have been encountered in observing nematodes in citrus feeder roots because of the presence of suberin and other unsaturated compounds. To obviate these difficulties, infected citrus roots, either fresh or preserved, are immersed for 2 hours at 52°C in a covered jar in a solution composed of 16 parts distilled water, 10 parts of 10 per cent acetic acid, and 2 parts of 2 per cent aqueous osmium tetroxide. The stained, blackened roots are washed in running water for at least 1 hour and then bleached in 10–30 per cent hydrogen peroxide at 32°C for a few seconds until the color of the roots lightens perceptibly. After several washings in water to stop the oxidation reaction, roots are dehydrated in 70, 95, and 100 per cent ethanol. They are held at 52°C for 30 minutes at each concentration. Following dehydration, roots are cleared in methyl salicylate at 52°C. Direct observation for nematodes, in many cases, can be made after 30 minutes.

Effect of radicle injury on growth and development of the peanut plant. TETER, N. C., AND LAWRENCE I. MILLER. SMJR Jumbo Runner variety peanut kernels were experimentally injured either by removing 0.75 to 1.25 mm of the radicle tip or by crushing the radicle tip with a force of 1800 grams. Injury of the radicle accentuated curvature of the hypocotyl, caused abnormal root development, and retarded foliar growth. In uninjured seed, hypocotyl curvature is determined by the position of the seed in the soil with respect to the radicle axis and the intercotyledonary plane. Injured seed commonly produced multiple primary roots that often fused. Instead of the normal 4-arch vascular pattern, the multiple primary roots had a variable number of vascular archs, and the cellular pattern of the stele was greatly disorganized and flattened. Leaflets of seedlings from injured seed unfolded slower and the plants from injured seed bloomed later than those from uninjured seed. Hypocotyl curvature and root abnormality observed in seedlings were also present in mature plants. Smaller kernels were produced from crushed seeds. Seed injury significantly reduced stands under normal cultivation practices.

Influence of soil temperature on reporduction of Meloidogyne spp. THOMASON, IVAN J. The ability of 3 root-knot

nematode species, *Meloidogyne incognita acrita, M. javanica,* and *M. hapla,* to reproduce on tomato (var. Rutgers) at soil temperatures of 20°, 25°, 30°, and 35°C was determined. After tomato plants had become established in a sandy loam, the soil was adjusted to the correct temperature, and approximately 5000 active larvae of the root-knot species to be tested were introduced into the soil of each 2-gal. pot. After 6 weeks, the plants were removed from the soil and the level of reproduction on the roots scored from 0 to 4 by the procedure outlined by Sasser. All populations of the 3 species of *Meloidogyne* tested reproduced at 20°, 25°, and 30°. Reproduction of *M. hapla* at 35° was extremely limited and inconsistent. That of 2 populations of *M. incognita acrita* and 1 of *M. javanica* was reduced markedly at 35°; only a few galls and egg masses were formed. A single egg-mass population of *M. javanica* from blackeye bean produced numerous galls and egg masses at 35°. Reproduction by this same population was slightly depressed at 20°. Viability of egg masses produced by populations of *M. javanica* and of *M. incognita acrita* at 35° was confirmed.

A cowpea local-lesion assay of presumably cherry ring-spot virus. THORNBERRY, H. H. Primary leaves of plants of *Vigna sinensis* (L.) Endl. (table cowpea, California Blackeye No. 5, Corneli lot No. 3125) have consistently given necrotic local lesions when mechanically inoculated with an infectious agent from some cherry sources. The agent has been transferred repeatedly to additional cowpea plants by mechanical inoculation with juice extracted from cowpea leaf tissues within a circular area of 3-mm diameter around local lesions and also from cowpea leaves containing several necrotic local lesions. Thus the lesions are reactions of the host to an infectious agent and not to a noninfectious toxic substance of the cowpea or cherry tissues. The infectious entity, presumably a virus, has been obtained from a mixture of the inflorescence, pedicels, and young leaves of sweet and sour cherry and of *Prunus mahaleb* L. growing from understock of sour cherry. The infectious entity most probably is cherry ring-spot virus, since it has been obtained from cherry trees originally indexed as ring-spot free but subsequently inoculated by grafted tissue containing a known strain of cherry ring-spot virus, Goldman 2-1 of D. Moore. Local lesions have not been obtained on other varieties of cowpea tested.

The effect of location and races on the epidemiology of Phytophthora infestans. THURSTON, H. DAVID, CARL J. EIDE, AND KENNETH KNUTSON. The spread of *Phytophthora infestans* on potatoes in a plot on upland silt-loam soil was compared with that on low-lying peat soil during 1952-54, inclusive. A single plant in the center of each plot was inoculated. Judged by the presence of late blight lesions, the fungus generally spread from plant to adjacent plant, instead of at random over the entire plot. Two or more distinct spreads always occurred before all of the plants in a plot (56×125 ft.) were infected. Weather data indicated that in 1953 and 1954 there were more periods favorable for sporulation and reinfection in the plot on peat than in that on the silt loam. As expected, the fungus spread more rapidly in the peat plot than in the other. In 1952, there were slightly more favorable periods on the peat plot than in the silt loam plot; nevertheless, the fungus spread more rapidly in the silt loam plot. Smaller plants and consequent better aeration in the peat plot afford a possible explanation for this. In 1954, plants in a plot on silt loam were inoculated with race 1 and those in an identical plot (400 ft. away) with race 0. Race 0 spread much faster than did 1, indicating that it may be the more aggressive of the 2.

Factors influencing the elimination of loose smut from barley by water-soak treatments. TYNER, L. E. Water was added to Glacier barley in amounts of 5, 10, 15, 20, 25, 30, 35, and 40 per cent and the seed sealed in flasks for 48 hours. Loose smut was eliminated from 85 to 100 per cent of the seed by the last 5 treatments but was little affected by the first 3. Loose smut was as effectively eliminated from barley immersed in running water for 54 hours as in standing water or in water changed at 5 intervals during this period. Wheat germ was steeped in water for 60 hours and portions of the liquor were 1) passed through a Seitz filter, 2) heat sterilized, and 3) left untreated. Loose smut was completely controlled in barley by immersing the seed for 20 hours in the first solution and almost completely controlled after 20 hours in the second. The third solution killed all seeds, and the first 2 reduced stand 50 per cent. It is suggested that quinones are the agents responsible for eliminating loose smut.

The amino-nitrogen nutrition of Pseudomonas lachrymans. —VAN GUNDY, S. D., AND J. C. WALKER. The susceptibility of cucumber as a host of *Pseudomonas lachrymans* was found to be in part dependent upon the relative level of amino nitrogen in the leaves. Mature leaves were most resistant; leaves approaching maturity were most susceptible. Averages of 4 readings per day for old and young leaves, respectively, were 3 and 6 mg carbohydrate and 100 and 200 μg nitrogen per g wet weight of leaf tissue. Highest disease development occurred in plants given high nitrogen or low potassium nutrients and least in those given low nitrogen. In leaf tests, the soluble carbohydrates remained nearly constant at all nutritional levels. Plants provided with high nitrogen contained as high as 5 times as much amino nitrogen as did plants very deficient in nitrogen. Plants deficient in potassium had a high level of amino nitrogen. When the amino nitrogen per g of wet weight was 100 μg or less, disease development was suppressed. Nutrition studies with 6 different isolates given various concentrations of asparagine and sucrose showed little increase in growth of the organism at levels below 100 μg asparagine N, regardless of the sucrose level. Increases in asparagine N above 100 μg rapidly reduced the requirement of sucrose for maximum growth in culture.

Pathogenic variation among isolates from bean plants with root rot. VAUGHN, JOHN R., AND CHARLES W. MCANELLY. In a search for inoculum with a consistently high level of virulence, more than 100 isolates from rotted bean roots were tested for pathogenicity in the greenhouse. About 95 per cent of the cultures were similar to *Fusarium solani.* The isolates were obtained from bean roots from several states in the western bean-growing regions. A rating scale of 0 to 4, based on the severity of root damage, was used. Average ratings from replicated plots varied from 0.23 to 4.00. Reisolation and successive testing showed that the level of pathogenicity was consistent, even though the average rating varied slightly in successive tests. Isolates with an average rating of 3.5 or better were saved to be used to test possible resistant material in breeding for resistance to bean root rot. Isolates with an average rating of less than 2.0 were discarded as not sufficiently pathogenic for these studies. Although some isolates decreased in virulence during culture for several months, those grown in sterilized field soil have maintained their virulence for more than a year.

Silicon content of the rice plant as a factor influencing its resistance to infection by Piricularia oryzae. VOLK, RICHARD J., ROBERT P. KAHN, AND ROBERT L. WEINTRAUB. The role of silicon nutrition in susceptibility of Caloro rice to infection by *Piricularia oryzae* Cav., the rice blast fungus, was studied with 3- to 10-week-old plants cultured in soil or nutrient solution. Susceptibility was measured by a quantitative bioassay and Si by a sensitive spectrophotometric micromethod. The Si content and resistance to blast of each leaf increases as the leaf ages. Accordingly, there exists at any moment an increasing gradient in Si content and in resistance from the younger upper leaves

toward the older basal leaves. The Si content of rice leaves was increased markedly by culturing the plants in silicate-rich nutrient solution. Such leaves were much more resistant to blast than were those of plants grown without added silicate. Withholding nitrogen from solution cultures also resulted in increased accumulation of Si, suggesting that resistance of young plants growing on low-N soils may be due to high Si content of the leaves. Analyses of field-grown plants support this hypothesis.

Dispersal of spores of Peronospora tabacina from tobacco blue mold lesions. WAGGONER, PAUL E., AND G. S. TAYLOR. The number of spores of *Peronospora tabacina* per m^3 of air 18 in. above the ground was measured hourly during 2 blue mold outbreaks in tobacco seedbeds. In the first, a Hirst spore trap was set in 480 sq. ft. of plants, all of which had active lesions. On a sunny, windy day spores first appeared in quantity at 4:30 a.m. and reached a maximum of 240/m^3 at the same time; none appeared at or after 8:30 a.m. On cloudy days, spores first appeared in quantity at 6 a.m. and reached maxima of 432–5000/m^3 at 9–10 a.m.; none appeared at or after 2–7 p.m. In the second outbreak, the trap was set among 96 sq. ft. of plants that had 200 lesions. On a cloudy day, spores appeared in quantity at 5 a.m. and reached a maximum of 90/m^3 at 6 a.m.; none appeared at or after 10 a.m. On 2 clear days following this, maxima of 6–12/m^3 appeared between 1 a.m. and 5 a.m. Evidently, each blue mold lesion causes an average of less than 1 spore to appear in each m^3 of air 18 in. above; the maximum number are air borne near sunrise, and few or no spores are air borne at night.

The influence of time and temperature on sporulation of Phytophthora infestans on potato leaves. WALLIN, JACK R., AND DALE N. POLHEMUS. Sets of 8 Russet Burbank potato plants bearing leaflet lesions 1 cm in diameter were placed in a dew chamber at 60°, 65°, 70°, 75°, 80°, or 85°F and removed in pairs after 6, 8, 10, or 12 hours. After each exposure period, the number of sporangia per lesion was estimated. Sporangia were produced after 6 hours at 70°, 75°, or 80°. At 60 and 65°, sporangia were evident after 8 hours. At 85°, sporangia were not noted until 10 hours. The quantity of sporangia produced by all isolates increased with time, but the extent of the increase varied among isolates. Sporangia produced by all isolates at all times and temperatures were viable except those produced by 1 isolate at 80° and by those at 85°. On the susceptible host, time and temperature revealed differences in the capacity of isolates to sporulate.

Population trends of nematodes associated with white clover in Louisiana. WEHUNT, E. J. Populations of nematodes in white clover (*Trifolium repens*) were studied during 1955-56 in field-plot fumigation experiments in Louisiana. Nematode numbers were determined monthly by suitable sampling, extraction, and counting procedures; plant growth was assayed every 4 months in the plots. Maximal plant growth of white clover occurred from January to June of 1956 and nematode populations likewise were highest during this period. The general trend of populations of *Pratylenchus* sp. and *Tylenchorhynchus* sp. varied with the period of maximal growth of white clover.

Loose smut control by anaerobic treatment due to loss in viability of infected seed. WEIHING, JOHN L., AND J. M. DALY. Loose smut of barley can be controlled by soaking seed in water for 15 minutes to 4 hours and then storing it in an oxygen-free atmosphere for 36, 48, or 60 hours, depending on temperatures. Hebert, who developed this method, suggested that control is effected by the inability of the fungus to survive in the absence of oxygen. The possibility that control is due to loss of viability of infected seed was not taken into account. Preliminary experiments indicated this to be the case. A more detailed replicated field trial was subsequently conducted. Seed was soaked for 3 hours and then placed for 24 or 36 hours at 28°C in Warburg vessels in which the air was replaced with nitrogen. Carbon dioxide from the respiring seed was absorbed with KOH. The seed was planted in 4 replicates, 100 seeds per replicate. When expressed as percentage of the seeds planted, the data for check, 24-hour treatment, and 36-hour treatment, respectively, were as follows: mature plants, 88.0, 81.8, and 75.8 per cent; smutted plants, 13.3, 8.0, and 1.5 per cent; nonsmutted plants, 74.8, 73.8, and 74.3 per cent. The data indicate that smut control through anaerobosis results from failure of infected seed to produce mature plants.

Stimulation of germination of spores of Piricularia oryzae by sapogenins. WEINTRAUB, ROBERT L., WILLIAM E. MILLER, AND EDWARD J. SCHANTZ. Germination on agar of spores of *Piricularia oryzae* Cav., the causal organism of rice blast, is accelerated by a factor present in rice polish and in rice oil. Similar activity is found in peanut and okra seed oils. The stimulator acts to accelerate the formation of germ tubes; it does not increase the fraction of the population that ultimately germinates. The active factor in rice oil is thermostable. It is found in the nonsaponifiable fraction of the oil and is associated with the steroidal components. Of a number of pure steroids tested, only the sapogenins showed comparable activity. Several of this class of substances were effective. A germination-accelerator was demonstrated in the dew and guttation liquid collected from rice leaves, an indication that such materials may play a natural ecological role. The rice oil factor and sapogenins also stimulate germination of uredospores of the wheat stem rust fungus.

Manganese nutrition of Nicotiana tabacum in relation to multiplication of tobacco mosaic virus. WELKIE, GEORGE W., AND GLENN S. POUND. Multiplication of tobacco mosaic virus was studied in *Nicotiana tabacum* L. grown in water-culture vessels containing a complete nutrient solution except for manganese, which was supplied at various concentrations or omitted. Plants grown under manganese-deficient conditions were stunted and developed intervenial chlorosis followed by complete chlorosis and necrosis. Virus-infected manganese-deficient plants exhibited less chlorosis than did noninfected plants that were deficient in manganese. Virus symptoms of manganese-deficient plants were less pronounced than those of plants receiving complete nutrient solutions. Both optical-density and local-lesion assays of virus extracts from homogenates of frozen whole plants, leaves, and leaf discs showed up to 50 per cent more virus per unit weight of tissue from manganese deficient plants than from control plants. The use of expressed sap instead of homogenates made on a fresh-weight basis and on oven-dried leaf tissue homogenized on a dry-weight basis yielded similar results. Uniform leaf discs of manganese-deficient plants, when compared to control tissue, proved to have a greater fresh weight, a lower dry weight, and nearly 40 per cent less total nitrogen. Leaf thickness of manganese-deficient tissue was about 18 per cent greater than that of normal tissue because of slightly enlarged and more loosely organized cells in the former.

Some observations on the pathological histology of downy mildew of corn, oats, sorghum, and wheat. WHITEHEAD, MARVIN D. Systemic infections by *Sclerophthora macrospora* result in cell hypertrophy and hyperplasia. In leaf tissue of foliate tassels, the intercellular spaces surrounding the vascular sheath cells, especially of the secondary vascular bundles, are the primary center of mycelial development. The sheath and later the phloem cells are pushed aside as individual mycelial strands enlarge to form large globular protoplasmic masses encased in a thin wall that later may become thickened. Oospores are formed in close association with the vascular bundles. The

xylem vessels become much enlarged, distorted, and closely appressed to the developing oospores. Host cells surrounding developing oospores become thick walled. Alternate regions of leaf, sheath, and husk tissues are thickened to as much as twice normal, causing the outer surfaces to be macroscopically roughened and warty. Increased cell and vascular development and oospore formation incite the distortion. Less extensive study of diseased oat, sorghum, and wheat material revealed a parallel development of host-parasite relationship. The malady is reported for the first time as a parasitic disease of sorghum.

Entry of wheat stomata by Puccinia graminis var. tritici and development of the fungus on dried plant surfaces. WILCOXSON, ROY D. Urediospore germ tubes of *Puccinia graminis* var. *tritici* enter wheat chiefly through open stomata, in either light or darkness. Rust flecks were as numerous on wheat seedlings inoculated with large quantities of urediospores of races 15B or 56 in lighted moist chambers as on plants in darkened chambers. Results were similar with race 15B on adult plants of Marquis and Webster. In similar experiments, flecks in numbers that approached significance at the 5 per cent level developed when Thatcher × Surpresa seedlings were inoculated with small quantities of race 15B spores. On seedlings in darkness, 75 per cent of substomatal vesicles formed under open stomata. From 4 to 30 per cent of stomata were open on leaves and stems of adult and seedling wheats that were in darkness 24 hours. Germ tubes of the stem rust fungus on air-dried (50 per cent relative humidity) plant surfaces continued to develop and penetrate the host. When epidermal strips were collected directly from plants in the moist chamber and from comparable plants air dried for 15 hours, no more germ tubes of race 15B appeared; however, appressoria doubled and substomatal vesicles quadrupled in number. Substomatal vesicles continued to form for 56 hours. Greater numbers of vesicles and pustules formed on plants held at 65°F 8 hours after the moist-chamber period than on plants at 75°F or at fluctuating temperatures.

Resistance to root-knot nematode in cotton. WILES, A. B. Eight-in. pots of steam-sterilized soil were separately infested with pure cultures of *Meloidogyne incognita*, *M. incognita* var. *acrita*, *M. arenaria*, *M. javanica*, and *M. hapla*. Inoculum consisted of about 10 g of heavily infested tomato roots. Seed of the various cottons to be tested were sown directly into the infested soil. There were 6–8 plants per pot and 5 replications. Tests were conducted in the greenhouse at a time when high temperatures could be maintained. After 4 months, the roots of the plants were examined and classified for nematode injury. Four varieties of *Gossypium hirsutum* (Auburn 56, Coker 100 Wilt, Alabama Hybrid 81-14, and Empire) that are resistant to Fusarium wilt and 1 (Fox) that is susceptible were tested. *M. incognita* var. *acrita* was moderate on Auburn 56 and severe on Coker 100 Wilt, Alabama Hybrid 81-14, Empire, and Fox; M. *incognita* was slight on Auburn 56, Coker 100 Wilt, Alabama Hybrid 81-14, and Empire and moderate on Fox. *M. hapla*, *M. arenaria*, and *M. javanica* caused no visible galling on any variety. High resistance to *M. incognita* var. *acrita* was found in *G. barbadense* var. *darwinii*. In crosses between *G. hirsutum* and *G. barbadense* var. *darwinii*, the F_1 progeny were susceptible.

Determining the inoculum potential of Verticillium in soil and predicting subsequent wilt losses in strawberry. WILHELM, STEPHEN. Because wilt losses in strawberry due to Verticillium reflect largely the previous susceptible crop or weed history of the land, a method of foretelling possible losses prior to planting of strawberries would be of great practical value. The previously described technique of estimating inoculum potential by determining an arbitrary infection index of soil samples proved useful. Approximately 50 8-in.-pot samples of soil were collected from each field studied. Soil samples from 8 fields, which (following tomatoes) were planted for 8 to 25 years to nonsusceptible crops or which were in fallow, gave infection indices of 0–3, with positive indices in fewer than ⅓ of the samples. In 1 such indexed field, plant losses in strawberries due to Verticillium wilt were less than 5 per cent. In 4 fields with tomato histories for 5 or fewer years prior to planting the strawberry crop, usually more than ⅓ of the samples yielded Verticillium and gave indices greater than 3. In 1 such indexed field, plant losses due to wilt were greater than 50 per cent.

Chloropicrin gives promising control of Verticillium wilt in strawberry. WILHELM, STEPHEN. In laboratory studies, Verticillium test inoculum (*V. albo-atrum*) was buried directly in 1 cu. ft. of infested field loam soil at depths of 1½, 3, 6, 9, and 12 in. and exposed to volatile liquid fumigants. Fungicidal activity was determined on the basis of recovery of viable Verticillium from the buried test inoculum and upon determination of infection indices of the infested field soil used. Chloropicrin was outstanding in fungicidal properties against Verticillium at 3 ml per sq. ft. injected 6 in. deep into soil whose moisture control at the surface was optimal for planting. This last point obviated a water seal. Small-scale and commercial field-machine-applied tests at 480 lb. per acre have achieved outstanding control of wilt and given exceptionally vigorous plants. The control has lasted through 2 years. Reinvasion of the fumigated soil by *Pythium ultimum* with attendant killing of feeder rootlets appears to be a primary factor causing decline in plant vigor in fumigated fields.

A survey of the degree of host infestation by Meloidogyne hapla in a 10-acre field of muck planted to vegetables. WILSON, J. D. Failure to obtain reliable data on the yield of various vegetable crops in muck area known to be heavily, but unevenly, infested with the root-knot nematode made it seem advisable to determine the effect of these obvious variations in nematode population on the yield of these crops. The area was divided into approximately 250 plots, each 24 × 55 ft. in size. The whole field was then planted to alternating 6-ft. strips of carrot, onion, celery, and potato. In addition, 5 dwarf tomato plants were set among the celery plants in each plot to provide a further index of nematode infestation. The results indicate that the degree of nematode infestation on carrots varied from less than 5 per cent in one plot to as high as 80 per cent or more within a distance of 50 ft. The same was true for the tomato and celery indexes. An area planted for 4 successive years in onions was nearly devoid of nematode damage, whereas adjacent plots previously planted to celery and/or carrots showed heavy infestation of the index plants in 1956. Plots adjacent to a driveway along 1 side of the field were rather uniformly infested, indicating a continuous distribution of nematodes by cultural tools.

Droplet size versus control efficiency of fungicidal spray applications. WILSON, J. D., AND ORVE HEDDEN. When the droplet size of a 1–100 spray formulation of maneb was varied from 100 to 500 μ in the spraying of different plots of potato and tomato plants, there was comparatively little variation in the degree of control of Alternaria (early) blight. The variations in droplet size accompanied various combinations of pressure and volume that varied from 277 to 20 lb./sq. in. and 80 to 20 gal. per acre, respectively. The relative spray droplet sizes for each type and size of nozzle used were determined by collecting and measuring drops from sets of replicated samples taken at several locations in the nozzle spray patterns under controlled laboratory conditions.

Inheritance of resistance in tomato to root knot nematodes. WINSTEAD, N. N., AND W. S. BARHAM. A tomato breeding line obtained from the Hawaii Experiment Sta-

tion has been found resistant to 4 species of root knot nematodes (*Meloidogyne incognita, M. incognita acrita, M. javanica,* and *M. arenaria*) and susceptible to one, *M. hapla*. Each of the 4 species was used to inoculate tomato seedlings, in the 5- to 7-leaf stage, of the resistant line Hawaii 5229, the susceptible line Step 174, the F_1 and F_2 of a cross between these 2 lines, and the backcrosses of the F_1 to each parent. A mixture of the 4 species also was used as inoculum. Two months after inoculation, plants were evaluated for the incidence of root knot. Results confirmed the conclusion of Gilbert and McGuire, who developed Hawaii 5229, that resistance to *M. incognita* is monofactorial. Data also indicated that the same gene controls resistance to each of these 4 species and that the resistance is incompletely dominant.

Origin of vectorless strains of potato yellow dwarf virus. WOLCYRZ, SYLVIA, AND L. M. BLACK. Antiserum produced by injecting a rabbit with New York potato yellow dwarf virus, which had been recently transmitted by the vector, reacted with the homologous virus and with the New Jersey variety of the virus. Following absorption of this antiserum with the New Jersey virus, also recently transmitted by its vector, the antiserum reacted only with the New York virus. An antiserum specific for the New Jersey virus was produced by a similar procedure. Only antiserum specific for the New York virus reacted with the 3 vectorless strains of potato yellow dwarf virus previously reported. This indicates that all 3 vectorless strains were derived from the New York virus. According to the laboratory record, covering 15 years of serial passages of viruses in *Nicotiana rustica*, 2 of the vectorless viruses were derived from the New Jersey variety. The serological evidence indicates that the less invasive New Jersey virus may have been replaced by contamination with the more invasive vectorless New York virus.

Juice transmission of viruses to peach. YARWOOD, C. E. Peach yellow bud mosaic virus has been mechanically transmitted to 126 of 265 inoculated peach trees in the greenhouse. Of several inoculation methods tested, the most successful was the rubbing of the upper stems and lower surfaces of the upper leaves with diluted juice from cowpea plants in the shock stage of infection with the virus. Inocula from peach trees in the shock and chronic stages of infection and from cowpeas in the recovered stage of infection were also infectious on peach, but inoculum from cucumber was not. Addition of phosphate or sulfite to the inoculum, the use of tissue instead of juice as inoculum, and the heating of the peach trees before or after inoculation have not increased transmission greatly, if at all. Symptoms on peach appeared in as few as 6 days, but considerably longer periods usually were required. A strain of ring spot virus from apricot was transmitted by juice from Pinto bean to 7 of 21 inoculated peach trees. A virus from Himalaya blackberry was transmitted from cowpea to 1 of 25 inoculated peach trees. Apple mosaic virus was transmitted from tobacco to 1 of 137 inoculated apple trees.

Heat activation of some virus infections. YARWOOD, C. E. When primary leaves of bean were heated 3–24 hours after inoculation, the number and size of local lesions resulting from inoculation with tobacco mosaic virus (TMV) or with apple mosaic virus were increased as much as 20-fold over those on unheated leaves. With TMV on Pinto bean, the greatest increase in number of lesions resulted from dipping leaves in water at 50°C for 25 seconds 6 hours after inoculation. Postinoculation heating was less effective than preinoculation heating in increasing the number of TMV lesions on bean. When cucumbers that had passed the age of greatest susceptibility were heated for about 20 seconds at 50°C as late as 5 days after inoculation with alfalfa mosaic virus, apple mosaic virus, spotted wilt virus, or peach yellow bud mosaic virus, the number of systemically infected plants was increased. Postinoculation heating of beans inoculated with alfalfa mosaic virus delayed the appearance of the local lesions, but the lesions that later appeared were more numerous and larger than those on unheated leaves. Systemic infection of cucumbers with TMV has resulted only on plants heated after inoculation.

Symptomology of some Mexican bean virus isolates. YERKES, WILLIAM D., JR., AND ALFONSO CRISPÍN MEDINA. Yellow mosaic bean virus, isolated from field beans at Cotaxtla, Veracruz, and identified by passage through sweetclover, produced symptoms in beans of the Canario race very similar to those incited by "curly top" virus. There was extreme shortening of internodes, and the trifoliate leaves puckered and curled downward. Even with early infections, however, the plants recovered and produced a few pods with viable seed. These seeds produced healthy plants. When U.I. Pinto varieties were inoculated with expressed juice from the plants with "curly top" symptoms, typical yellow bean mosaic symptoms were produced. Isolates of common bean mosaic virus from Mexico, when compared with isolates of this virus from the U. S., gave reactions similar to those caused by bean virus 1 (typical strain) on standard differentials. When Mexican bean varieties were inoculated with the 2 kinds of isolates, the Mexican isolates produced much more severe symptoms than did the U. S. isolates. This indicates the possible existence of a more virulent strain of common bean mosaic virus in Mexico than is present in the U. S.

Cultural and chemical treatments for control of the early maturity disease of potatoes. YOUNG, ROY A. AND W. J. TOLMSOFF. The early maturity disease of potatoes annually causes yield losses on several thousand acres in south central Oregon. *Verticillium albo-atrum*, the principal cause of disease, can be isolated from vascular tissues throughout diseased plants. *Fusarium* sp. and *Pythium* sp. can be isolated from roots, and a species of *Colletotrichum* frequently can be isolated from crowns of diseased plants. The disease, which is most severe on light, sandy soils, was partially but not effectively controlled by applying optimum quantities of nitrogen fertilizers, by crop sequences involving cereals as a preceding crop, and by seed-piece treatment with dichlone or Semesan Bel (3.2 per cent 2-chloro-4-(hydroxymercuri) phenol and isomers; 12 per cent 4-(hydroxymercuri)-2 nitrophenol and isomers). Several chemicals have been tested as soil fungicides for control of the disease. Soil treatment with 190 lb. of Vapam (sodium methyldithiocarbamate) per acre was extremely effective in 1955. When land treated in 1955 was replanted to potatoes in 1956, residual effects of the treatment were apparent in both disease control and weed control. In dosage-rate trials in 1956, a significant degree of control was obtained with rates as low as 40 lb. of Vapam per acre.

Vapam as a soil fumigant and as a chemotherapeutant. ZENTMYER, GEORGE A., AND J. L. ERSPAMER. One hundred twenty-five avocado trees affected with Phytophthora root rot in southern California were treated with varying dosages and gallonages of Vapam (sodium *N*-methyldithiocarbamate) in attempts to 1) eliminate the fungus without regard to tree health or 2) reduce the fungus population in small feeder roots and soil (and thus encourage tree recovery) with nonphytotoxic or slightly phytotoxic dosages of the fungicide. Application was mainly by sprinklers, with the material injected into irrigation lines under pressure. With dosages of 200-250 ppm (active ingredient) at 3–4 gal./sq. ft., kill of *Phytophthora cinnamomi* was obtained to the depth of sampling (24 in.), with no recovery of the fungus 9 months to 1 year after treatment in some cases. With treatment at therapeutic levels, root infection with *P. cinnamomi* was strikingly less when

solutions containing 50, 75, or 100 ppm (active ingredient) Vapam were used. Infection gradually increased but after 1 year was still significantly lower than before treatment. Tree injury was appreciable even at lower dosages in some cases, particularly on weak trees, and was severe when temperatures were high at the time of or following treatment. Methyl bromide, chloropicrin, and D-D (1,3-dichloropropene; 1,2-dichloropropane) were also effective fumigants against *P. cinnamomi* but are impractical for large-scale field use.

Effects of ultrasound and several chemicals on certain properties of the oak wilt fungus. ZUCKERMAN, B. M. The oak wilt fungus, *Endoconidiophora fagacearum* Bretz, was subjected to several sublethal dosage levels of ultrasound. Ultrasonic irradiation did not affect rate or percentage of germination of conidia, growth in a liquid medium, exometabolite production as assayed by pH change in the medium and by toxicity of cultural filtrates to tomato cuttings, pathogenicity, or ability to form fertile perithecia. The pathogen was grown in sublethal concentrations of 3 chemicals that apparently had chemotherapeutic properties against the fungus in culture. Exometabolite production, ability to form fertile perithecia, pathogenicity, and growth in liquid medium were not altered by these treatments. The fungus was reisolated from a tree that apparently had been successfully treated with a chemotherapeutant. When this isolate was grown in a liquid medium, pH changes in the substrate, growth, toxicity of the substrate to tomato cuttings, pathogenicity, and ability to form fertile perithecia were not changed from normal.

HYDRANGEA RINGSPOT VIRUS, THE PROBABLE CAUSE OF "RUNNING-OUT" OF THE FLORISTS' HYDRANGEA[1]

Philip Brierley and Paul Lorentz[2]

SUMMARY

Hydrangea ringspot virus was found to be transmissible by mechanical methods and by the cutting knife, but not through seed. It produced distinctive local lesions in *Gomphrena globosa* after 5 to 6 days. Other local-lesion hosts are *Amaranthus retroflexus, Chenopodium album, C. amaranticolor,* sugar beet, cucumber, snapdragon, and sweet william. *Hydrangea macrophylla* is the only host known to be systemically invaded. In unpurified extracts from hydrangea, the virus withstood heating to 74°C, dilution to 10^{-5}, and aging for 14 days. Hydrangea ringspot was present in all commercial varieties tested. The majority of varieties are tolerant to this virus, and only Charm and Sainte Speer are known to be unsalable when infected. Tomato ringspot virus also was found to be transmissible from hydrangea to Gomphrena. No evidence was found that tomato ringspot virus is carried on the cutting knife or through seed of florists' hydrangea.

Old leaves of florists' hydrangeas (*Hydrangea macrophylla* (Thunb.) DC.) frequently show symptoms consisting of chlorotic or brown rings, or oakleaf patterns, caused by a virus that is sap transmissible to seedling hydrangeas but not to tobacco (*Nicotiana tabacum* L.).[3] Such symptoms appeared in 2 of 59 seedling clons furnished us by Conrad B. Link, of the University of Maryland, in 1952. Occurrence of these symptoms in plants of recent seed origin suggested that the causal virus might be either seed borne or transmissible on the cutting knife. Studies on transmission, hosts, prevalence, and properties of this virus are reported in this paper. An abstract and a brief account of some of the results have been published previously.[4,5]

GENERAL MATERIALS AND METHODS.—Six of 59 seedling clons of the florists' hydrangea supplied by C. B. Link were increased vegetatively to serve as test material, and 2 that expressed ringspot symptoms were retained as source material for the virus. Other source plants were selections from 2 commercial varieties of hydrangea, Strafford and Merveille, and inoculated seedlings from previous studies.

In sap-transmission trials, leaves of hydrangea were ground with 1 per cent $Na_2HPO_4 \cdot 12H_2O$ or K_2HPO_4,

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[2] Pathologist and Agricultural Aid, respectively, Horticultural Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

[3] Brierley, P. 1954. Symptoms in the florists' hydrangea caused by tomato ringspot virus and an unidentified sap-transmissible virus. Phytopathology 44: 696-699.

[4] Brierley, P., and P. Lorentz. 1956. Detection and transmission of hydrangea ringspot virus. (Abs.) Phytopathology 46: 466.

[5] Brierley, P. 1956. Susceptibility of Gomphrena to tomato ringspot virus. U. S. Dept. Agr. Pl. Dis. Rptr. 40: 667.

and the resulting crude extract was rubbed over leaves of test plants previously dusted with Carborundum powder. Yarwood's fresh-leaf method[6] was used also, but, in general, it proved less effective than sap transmission. Details on attempts to transmit the virus on the cutting knife and through seed are described in later sections. All tests with hydrangeas were continued at least a year to permit full expression of symptoms. During the fall or winter, plants were stored at 1.7° or 4.4°C for 6 weeks so that they would develop normally.

SYMPTOMS IN THE FLORISTS' HYDRANGEA.—Hydrangea varieties vary in tolerance to the hydrangea ringspot virus. The more tolerant varieties, Strafford, Engel's White, Todi, and Monte Forte Perle, generally show no symptoms during the forcing period. Rose Supreme and Sainte Therese occasionally express yellowish blotches or rings on lower leaves before flowering. Merveille, a leading commercial variety, is less tolerant than Strafford or Engel's White, and during the forcing period frequently shows conspicuous yellow blotches and chlorotic rings in green leaves, and occasionally reddish-brown rings also. Shaded or suppressed leaves of Merveille and other varieties often show a reversal pattern, green rings on a yellow ground. The leaves of the variety Charm are conspicuously distorted, and infected plants are unsalable. Development of the midrib is checked about midway from base to the tip of the leaf, and the lamina becomes strikingly curled or waved at this point. The lower leaves are more nearly flat, and they have irregular yellow blotches or rings. The upper leaves of Sainte Speer show milder curling but no characteristic ring patterns. This variety is severely dwarfed and produces few florets per head, but the individual ones are normal in size and shape. Except for the suppression of floret number, no recognizable flower symptoms are associated with the hydrangea ringspot virus, and the virus titer is much lower in sepals than in adjacent leaves.

The seedling clons used as test material, produced by C. B. Link by hybridizing commercial varieties, are relatively tolerant to the virus. After flowering, inoculated plants of these clons develop chlorotic blotches or well-defined chlorotic rings (Fig. 1,B). Affected plants that are held in the greenhouse through November and December often express reddish-brown blotches and rings (Fig. 1,C). Thus, expression of ringspot symptoms appears to be characteristic of mature or overmature leaves. In N. W. Stuart's nutritional experiments, the variety Merveille grown at below-normal levels of nitrogen expressed chlorotic rings freely, whereas the same variety grown at high-N levels rarely showed symptoms. In general, expression of symptoms of hydrangea ringspot by florists' hydrangeas is too erratic for reliable direct diagnosis.

[6] Yarwood, C. E. 1953. Quick virus inoculation by rubbing with fresh leaf discs. U. S. Dept. Agr. Pl. Dis. Rptr. 37: 501-502.

TRANSMISSION. — *Mechanical transmission.* — Sap transmission from 5 selected source plants was attempted to determine whether the viruses present were transmissible and whether they produced similar symptoms in hydrangea. The 2 ringspot contaminants in Link's seedling clons were compared with 2 other selections of hydrangea ringspot virus and with the viruses in commercial Strafford, known to carry tomato ringspot virus as well as hydrangea ringspot virus. Inoculations were made to 10 hydrangea seedlings from each of these 5 sources. Young leaves were inoculated in March, 1954, 1 month after the plants were returned from storage to the greenhouse. Symptom expression was poor during the first year, but in the second season of growth, March to November, 1955, 5–10 of the 10 plants inoculated in each set developed typical chlorotic or reddish-brown rings. Symptoms characteristic of those induced by tomato ringspot virus appeared only in the 1 series in which this virus was known to be present. Tomato ringspot virus is also transmissible from hydrangea to *Gomphrena globosa* L. and produces solid gray spots after 6–10 days. This virus, unlike hydrangea ringspot virus, becomes systemic in Gomphrena and infects tobacco. Indexing the plants on tobacco revealed tomato ringspot virus in 5 of 10 plants of that series and in none of the other series. The hydrangea ringspot virus from all 4 sources caused uniform symptoms.

Sap transmission to Gomphrena from all hydrangeas that showed chlorotic or reddish-brown rings was uniformly successful. This was true also of tolerant types that showed no rings. The relatively slow method of grinding test leaves in a mortar in the presence phosphate buffer was used in all indexing. Short methods such as Yarwood's fresh-leaf method produce far fewer local lesions in Gomphrena, presumably because less inoculum is applied to the test leaves. Therefore, the long method is preferred as it is more likely to reveal the hydrangea ringspot virus if it is present in low titer.

Return inoculations from Gomphrena to a hydrangea seedling clon were made in November, 1955. Five plants were inoculated by sap and 5 by the Yarwood fresh-leaf method. In March, 1956, 4 months after inoculation, the virus was found, by indexing, in all 10 inoculated plants. No ring symptoms appeared after 8 months. From past experience with such seedlings, symptoms may not appear for a year or more.

Transmission by cutting knife.—The source plants for experiments with the cutting knife were commercial Strafford hydrangeas previously found to carry the viruses of tomato ringspot and hydrangea ringspot. In 3 tests begun during the summer of 1954, a knife was passed through a young stem of such source material before it was passed through the base of each healthy hydrangea cutting. Cuttings thus exposed to the viruses were then placed at once in a rooting medium. The 267 cuttings thus exposed and 168 unexposed control cuttings were grown through 1954 and 1955 to permit development of symptoms. No symp-

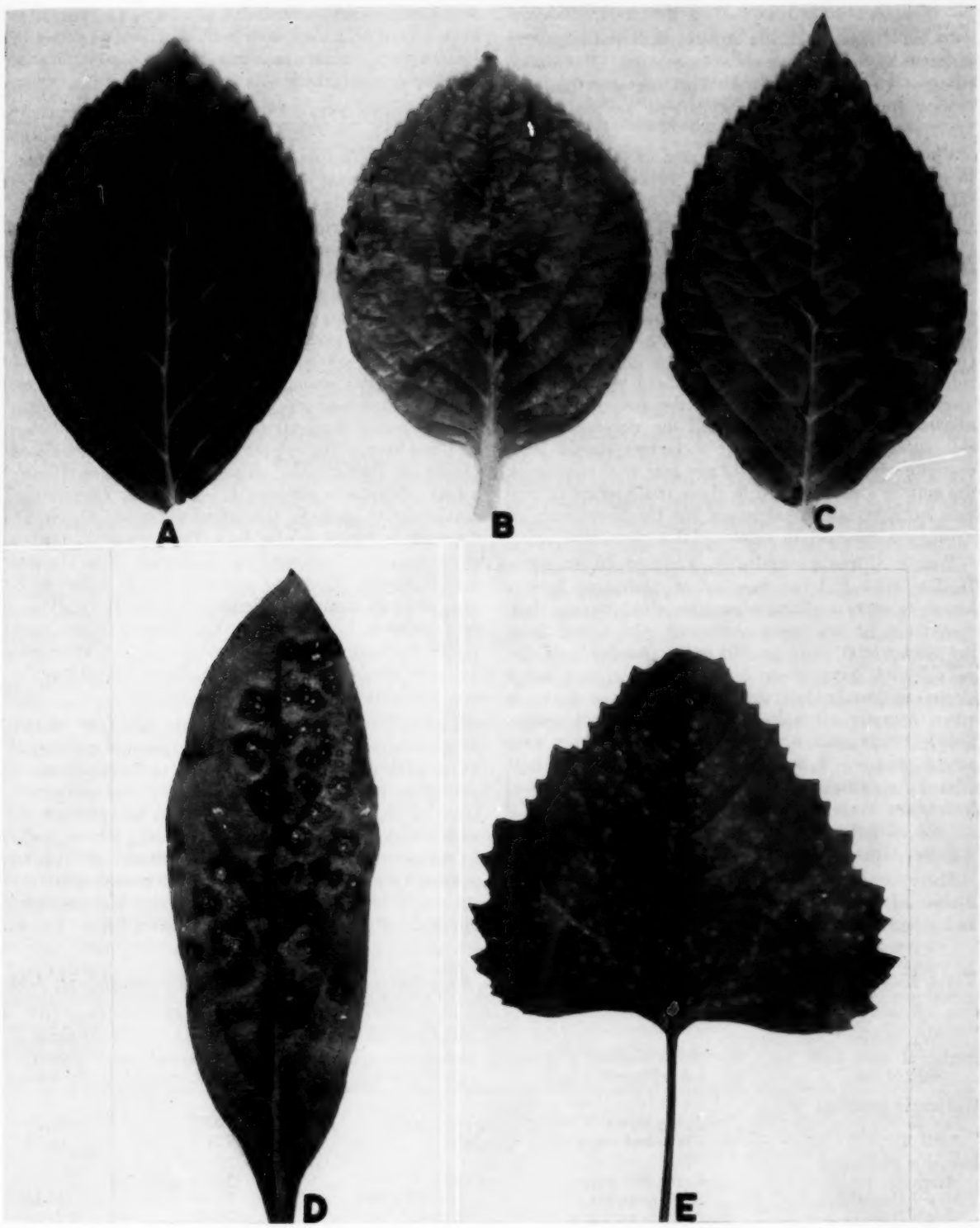

FIG. 1. Symptoms produced by hydrangea ringspot virus. A-C) *Hydrangea macrophylla* (× ½). A) Healthy leaf. B) Leaf with chlorotic blotches and rings. C) Leaf with reddish-brown rings. D) Local lesions in *Gomphrena globosa* (× 1). E) Local lesions in *Chenopodium amaranticolor* (× 1).

toms were detected in these plants before they were placed in storage February 23 to March 30, 1955.

In September, 1955, the 267 exposed seedlings were indexed by sap transmission to tobacco. No tomato ringspot virus was detected. This indicates that the tomato ringspot virus is not carried on the cutting knife or at least not readily so.

Chlorotic ring symptoms appeared by October, 1955, in about 10 per cent of the 267 exposed plants. At this time, indexing by sap transmission to Gomphrena showed presence of hydrangea ringspot virus in 12 per cent of the 267 exposed plants and in none of the unexposed control plants.

In these tests the knife was recontaminated before cutting each healthy test plant, a condition unlikely to apply in commercial propagation. On the other hand, commercial propagating material is certainly more soft and succulent than the Strafford source plants used in these experiments, for the presence of the tomato ringspot virus prevented the development of soft succulent shoots. These 2 factors should have opposite effects, hence, the 12 per cent transmission on the cutting knife detected in these trials seems to provide an adequate explanation for the prevalence of hydrangea ringspot in commercial hydrangeas.

Failure of seed transmission of hydrangea viruses.—During 1954 a large number of hydrangea plants known to carry hydrangea ringspot virus, tomato ringspot virus, or both were pollinated with pollen from the commercial varieties Merveille, Strafford, or Engel's White. Since these 3 varieties were later found to be uniformly infected with hydrangea ringspot virus, actually all pollen was from infected plants. Seed set was relatively poor, but 328 seedlings were produced from 7 successful crosses. All of these offered opportunity for possible seed transmission of hydrangea ringspot virus, and 78 seedlings from 4 crosses offered opportunity for transmission of tomato ringspot virus also.

These seedlings developed no symptoms of either disease. Indexing by sap transmission to Gomphrena and tobacco during March and April, 1956, revealed no evidence of either virus in any plant. Failure to demonstrate seed transmission of viruses in hydrangea is in accord with the experience that new varieties of hydrangea appear to be virus-free until contaminated by propagation practices.

HOSTS AND PREVALENCE OF HYDRANGEA RINGSPOT VIRUS.—When hydrangea ringspot virus proved so readily transmissible to hydrangea, a search for herbaceous test plants was begun in October, 1955. Source material consisted of some of the hydrangea seedlings, used in the experiments on cutting-knife transmission; these plants were infected and showed conspicuous chlorotic rings. Sap transmission from these seedlings induced local lesions in *Gomphrena globosa* L., *Amaranthus retroflexus* L., *Antirrhinum majus* L. (snapdragon), *Beta vulgaris* L. (sugar beet U. S. 401), *Chenopodium album* L., *C. amaranticolor* Coste & Reyn., *Cucumis sativus* L. (cucumber var. Marketer), and *Dianthus barbatus* L. (sweet william). The virus was recovered from all these hosts on subinoculation to Gomphrena. No symptoms appeared in inoculated plants of *Callistephus chinensis* (L.) Nees (China aster), *Capsicum annuum* L. (pepper), *Chrysanthemum morifolium* Ram. (chrysanthemum var. Dynamo), *Cyamopsis tetragonoloba* (L.) Taub. (guar), *Datura stramonium* L., *Lycopersicon esculentum* Mill. (tomato var. Rutgers), *Nicotiana glutinosa* L., *N. tabacum* L. (tobacco var. Samsum), *Petunia hybrida* Hort., *Phaseolus vulgaris* L. (bean var. Top Crop), *Silene compacta* Fisch., or *Zinnia elegans* Jacq.; the virus was not reisolated from any of these plants by subinoculation to Gomphrena.

In Gomphrena, local lesions are sometimes visible after 3 days as gray dots. These become red-ringed (Fig. 1,D) after 5–6 days, enlarge to 5-mm diameter, and when numerous become confluent and cause collapse of leaf tissue after 4–6 weeks. No systemic invasion occurs; upper leaves on plants whose lower leaves are infected are as readily infected as those on previously noninoculated plants. At greenhouse temperatures of 15° to 30°C, Gomphrena is a sensitive indicator plant for hydrangea ringspot virus, but at

TABLE 1.—*Physical properties of hydrangea ringspot virus in unpurified extracts tested on Gomphrena globosa, 1956*

Source of virus and date of test	Stage of plant development	Inactivation end points		
		Dilution	10-minute heating (°C)	Aging at 20°C (days)
Hydrangea seedlings				
Jan. 25	Aging leaves	10^{-3}–10^{-4}	70-80	12–20
April 18	Green-bud stage	$>10^{-5}$	72–74	12–14
Merveille hydrangea				
March 22	Green-bud stage	$>10^{-4}$	72–74	
May 9 (high-N)	After flowering	10^{-5}–0.2×10^{-5}	72–74	14-16
May 9 (low-N)	After flowering	10^{-5}–0.2×10^{-5}	70–72	5–10
Charm hydrangea				
April 19	In full bloom	$>10^{-5}$	74–76	
Gomphrena				
March 9	11 days after inoculation	10^{-3}–10^{-4}	65–70	

35° to 40° few or no local lesions develop. Gomphrena is inferior to hydrangea as a virus source (Table 1). The virus reaches highest titer about 10 to 14 days after inoculation, when the local lesions are still expanding. *Chenopodium amaranticolor*, supplied by C. W. Bennett, develops chlorotic local lesions 1–2 mm in diameter 6 days after inoculation with hydrangea ringspot virus (Fig. 1,E). Chenopodium is a slightly less sensitive indicator than Gomphrena and a poorer source of this virus. Other local-lesion hosts are less sensitive, slower to respond, or produce less clearly defined lesions; hence they are not recommended as index plants for detection of hydrangea ringspot virus.

When Gomphrena proved to be a useful indicator for hydrangea ringspot virus, this plant was used to determine prevalence of this virus in the hydrangea varieties available at Beltsville in conection with N. W. Stuart's nutrition and forcing studies. Random sampling of 2 older commercial varieties, Merveille and Engel's White, together with symptom expression by them, indicated 100 per cent infection. All 31 tested plants of Strafford, which expresses symptoms less freely, were found infected. Of 63 plants of Rose Supreme, a standard variety of more recent origin, 75 per cent were infected. In Charm, a variety of the novelty group, all 25 plants tested carried ringspot. In varieties recently introduced, hydrangea ringspot virus was present in 22 per cent of 77 plants of Sainte Therese, in all of 5 plants of Sanctis, in all of 5 plants of Zurich, in all of 20 plants Monte Forte Perle, and in all of 16 plants of Sainte Speer. In the variety Todi, not yet introduced to the florists' trade, 6.5 per cent of the 122 plants tested were found infected. Hydrangea ringspot virus was found also in all plants of small samples of Alphengluhn and Belgica, in 2 of 3 plants of Rêve Rose, and in 2 of 5 plants of Sainte Claire, varieties still under preliminary trial.

There is a tendency for older varieties to be uniformly infected and for new ones to be only partly infected; however, some new sorts become contaminated much faster than others. This may reflect exposure to different degrees of contamination hazards during their propagation. There is also a possibility that varieties differ in susceptibility to the hydrangea ringspot virus, as well as in tolerance to infection.

PHYSICAL PROPERTIES OF HYDRANGEA RINGSPOT VIRUS.—Property tests (Table 1) were made on the virus extracted from hydrangeas showing ring symptoms, except for 1 trial in which Gomphrena sap was tested for comparison. Virus from seedling hydrangeas infected in the experiments on cutting-knife transmission was tested at 2 seasons of the year, and virus from a tolerant variety, Merveille, and that from an intolerant variety, Charm, were compared with it. In the January test of seedlings, sap was extracted from aging leaves with prominent ring symptoms before the plants were placed in cold storage. In April, the same 10 source seedlings in green-bud stage served as source. The commercial variety Merveille was tested at green-bud stage in March and after flowering in May; Charm was tested at full bloom in April. In aging tests, the crude extract was stored in flasks at room temperature, which averaged 20°C.

Extracts from the intolerant variety Charm and from the tolerant variety Merveille showed little difference in titer. Virus titer appears to be at a uniformly high level throughout the forcing period but falls in aging leaves. The titer attained in Gomphrena is lower than in hydrangea. Although symptoms were largely suppressed in Merveille grown at a high nitrogen level, the virus titer in these plants proved higher than in those that were grown at a low nitrogen level and that expressed ring symptoms freely.

DISCUSSION.—Culture of the florists' hydrangea in the United States is based on use of varieties tolerant to hydrangea ringspot virus. The so-called "running-out" of some varieties appears to represent gradual contamination of intolerant sorts during propagation. There is thus far no evidence that the more tolerant varieties are significantly damaged by hydrangea ringspot virus, and consequently there is little incentive for a shift in propagation practice to protect the less tolerant new varieties against contamination. In most respects this problem is comparable with the chrysanthemum stunt problem except that tolerant varieties are not available in chrysanthemum whereas in hydrangea these predominate.

No short method is known for evaluating the capacity of new seedling varieties to tolerate the hydrangea ringspot virus. Whether these are purposely inoculated or contaminated by propagation practices, a year or more is required for expression of symptoms and for estimation of injury. If new seedlings are to be protected from contamination, the simple practice of setting them aside and propagating them first ahead of older commercial varieties, will prove helpful.

PLANT INDUSTRY STATION
BELTSVILLE, MARYLAND

EFFECT OF ANTIBIOTICS AND SURFACE-ACTIVE AGENTS ON BACTERIAL WILT OF SWEET CORN IN THE GREENHOUSE[1]

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SUMMARY

Four antibiotics and 9 surface-active agents were tested for control of bacterial wilt of sweet corn seedlings in the greenhouse. Plants were sprayed, then inoculated 24 hours later by hypodermic injection of *Bacterium stewartii* E. F. Sm. into the base of the culm. Symptoms on plants treated with terramycin or Acti-dione at concentrations of 50 ppm were less severe than those on similarly inoculated but unsprayed plants. Streptomycin and penicillin were ineffective at these concentrations. Acti-dione was very phytotoxic. Wilt control was enhanced by placing plants in a moist chamber for 24 hours after spraying with streptomycin or terramycin. The addition of 10,000 ppm glycerol to the sprays did not enhance control.

Development of bacterial wilt was partially inhibited by sprays containing 10,000 ppm of the following surface-active agents: Tween 20, Tween 40, Tween 60, Tween 80, Triton X-155, Ivory Flakes, and Dreft. Triton X-114 was effective at 1000 ppm and extremely phytotoxic at 10,000 ppm. Silver Dust was ineffective. Maximum control by Tween 20 was obtained when applications were made to both the expanded leaf blades and the "whorl." Tween 20, in agar at a concentration of 100,000 ppm (10 per cent), did not inhibit *B. stewartii*.

The discovery that streptomycin would control several bacterial diseases of plants and reports of its systemic action have stimulated interest in the use of antibiotics for plant disease control. Natti (7) reported that streptomycin sprays decreased the spread of bacterial wilt of corn in the field. This paper reports the effects of several antibiotics and surface-active agents on the development of bacterial wilt of sweet corn (caused by *Bacterium stewartii* E. F. Sm.) in the greenhouse. Field experimentations in Ohio in 1955 are reported elsewhere (5).

MATERIALS AND METHODS.—Potted Golden Bantam sweet corn (*Zea mays* var. *saccharanta* (Sturdev.) Bailey) seedlings in the 3-leaf stage were used as the test plants. Spray materials were applied through a small atomizer at 15 lb./sq. in. Plants were sprayed until run-off occurred, then allowed to dry for 24 hours before inoculation. Inoculations were made by injecting a standardized suspension of *B. stewartii* into the base of the culm by means of a tuberculin syringe (6). Disease ratings were made approximately 1 week after inoculation; severity of disease was estimated by a rating method (6) in which the 3 youngest leaves of individual plants were assigned a rating of 0 to 5, where 0 indicated a healthy and 5 a dead leaf. Six-pot replications of 6 plants each were used; the total of 18 ratings was divided by 18 and expressed as a mean. In general, such replications would differentiate ½ a rating unit between treatments (6).

The following antibiotics and wetting agents were used: streptomycin sulfate, potassium penicillin G, and Acti-dione (3-[2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl]glutarimide) (Upjohn Co.); terramycin (4-dimethylamino-1,4,4a,5,5a,6,11,12a-octahydro-3,5,6,10,12,12a-hexadydroxy-6-methyl-1,11-dioxo-2-naphthacenecarboxamide) hydrochloride (Chas. Pfizer Co.); Tween 20 (polyoxyethylene sorbitan monolaurate), Tween 40 (polyethylene sorbitan monopalmitate), Tween 60 (polyoxyethylene sorbitan monostearate), and Tween 80 (polyoxyethylene sorbitan monooleate) (Atlas Powder Co.); Triton X-114 (alkyl aryl polyether alcohol) and Triton X-155 (alkyl aryl polyether alcohol) (Rohm and Haas Co.); Silver Dust (a household detergent) (Lever Bros. Co.); Ivory Flakes (a household soap) and Dreft (a household detergent) (Procter and Gamble Co.). Concentrations were based on active ingredients except in the case of Silver Dust, Ivory Flakes, and Dreft, which were based on weight of material as formulated. All antibiotic preparations were carried in 1000 ppm Tween 20.

RESULTS.—*Antibiotics.*—Streptomycin, in several tests at concentrations of from 50 to 500 ppm, did not affect development of bacterial wilt symptoms (Table 1). Terramycin at 500 ppm gave a measure of control. Sprays of both materials at 500 ppm caused slight temporary chlorosis of some of the leaves.

Although indole-3-acetic acid and some other growth-regulating substances have been reported to improve control of fire blight (caused by *Erwinia amylovora* (Burr.) Winsl. et al) of apple when added to streptomycin spray formulations (1,4), solutions containing 50 or 500 ppm streptomycin plus 100 ppm indole-3-acetic acid did not control bacterial wilt of sweet corn in 2 tests in the present studies.

Symptoms on plants sprayed with Acti-dione at 50 and at 500 ppm were not as severe as those on the controls. Both concentrations caused severe injury to the older leaves, but those leaves emerging after application of the sprays were normal and showed little disease in comparison to control plants. Penicillin at 500 ppm gave no control and was not phytotoxic.

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TABLE 1.—*Severity of bacterial wilt in sweet corn plants sprayed prior to inoculation with various antibiotics*

Antibiotic	Disease index[a] of plants sprayed with indicated concentrations			
	0 ppm			
	1000 ppm Tween 20	No Tween 20	50 ppm	500 ppm
Streptomycin[b]	0.68	0.79	0.64	0.52
Streptomycin + 100 ppm indole-3-acetic acid[b]	0.68	0.79	0.69	0.48
Terramycin[c]	1.12	1.28	1.06	0.76
Acti-dione[d]	0.57	0.53	0.27	0.19
Penicillin[b]	0.57	0.53	0.55	0.48

[a] Three leaves on each plant were assigned a rating of 0 to 5, where 0 represented a healthy and 5 a dead leaf. Mean ratings for plants were used to calculate pot means the averages of which served as disease indices.
[b] No statistically significant difference.
[c] LSD at 5 per cent level was 0.27; at the 1 per cent level, 0.36.
[d] LSD at 5 per cent level was 0.17; at the 1 per cent level,0.23.

No therapeutic effects were observed when 1–4 spray applications of streptomycin at 200 ppm were made at intervals of 4 days to diseased sweet corn seedlings.

Streptomycin was tested as a treatment for seeds of sweet corn to determine if such treatment would protect subsequent seedlings from bacterial wilt. Golden Bantam seeds were soaked in streptomycin solutions of 40, 200, and 1000 ppm for 24 hours. The treated seeds were planted in soil in flats. Treatments were replicated 4 times with 25 seeds each. On emergence, the seedlings were cut at the level of the coleoptile tip and the cut ends dabbed with absorbent cotton dipped in a suspension of the wilt bacterium (6).

Nearly all the seedlings from seeds soaked in streptomycin at 1000 ppm were completely and permanently chlorotic. These seedlings were not diseased. Some of the seedlings arising from seeds soaked at 200 ppm were slightly chlorotic and were free from disease or only slightly diseased. There was no chlorosis nor effect on disease development when seeds were soaked in 40 ppm streptomycin.

The chlorosis-inducing effects of streptomycin on plants have been noted by other experimenters (8, 9,10,12). Whether the absence of or the lessened development of bacterial wilt was a result of the presence of bactericidal levels of streptomycin in the tissues or was related to the chlorotic condition induced by the streptomycin is unknown.

Surface-active agents.—One thousand ppm of Tween 20 was used routinely as the wetting agent for the antibiotic sprays. To determine if wetting agents themselves would have any effect on the development of bacterial wilt in seedling sweet corn plants, Tween 20, Tween 40, Tween 60, and Tween 80 were tested as sprays at concentrations of 1000 and 10,000 ppm.

Solutions of these materials at 10,000 ppm reduced disease development by about one-half (Table 2). Sprays of 1000 ppm did not affect bacterial wilt development. Solutions of the 4 Tween preparations at 30,000 ppm were generally no more effective than 10,000-ppm solutions. There were apparently no differences among the various Tween preparations in relative effectiveness in controlling bacterial wilt. These results were confirmed in several tests.

Solutions of 10,000 ppm of Tween 20, 40, 60, or 80 often caused injury to leaves or parts of leaves that emerged subsequent to treatment. Injured leaves were somewhat rugulose and mottled. There was no apparent injury to parts of leaves already expanded. Solutions at 1000 ppm were not phytotoxic.

Tween 20 and Tween 80 at concentrations of 1000, 10,000, and 30,000 ppm were tested as seed treatments for control of bacterial wilt of sweet corn. Soaking seeds for 24 hours in the Tween preparations had no effect on symptom development, and the solutions were not phytotoxic.

TABLE 2.—*Severity of bacterial wilt in sweet corn plants sprayed with various surface-active agents prior to inoculation*

Experiment No.	Treatment	Disease index[a] of plants sprayed with indicated concentrations			
		0 ppm	1000 ppm	10,000 ppm	30,000 ppm
1[b]	Tween 20	1.16	1.19	0.47	0.37
	Tween 80		0.99	0.57	0.36
2[c]	Tween 40	1.28	1.28	0.80	0.55
	Tween 60		1.35	0.82	0.37
3[d]	Tween 20	1.06		0.57	
	Tween 40			0.58	
	Tween 60			0.63	
	Tween 80			0.62	
4[d]	Triton X-114	1.60	1.26	toxic	
	Triton X-155		1.43	0.88	
5[e]	Silver Dust	0.70	0.59	0.54	
	Ivory Flakes		0.54	0.39	
	Dreft		0.59	0.33	

[a] Three leaves on each plant were assigned a rating of 0 to 5, where 0 represented a healthy and 5 a dead leaf. Mean ratings for plants were used to calculate pot means the averages of which served as disease indices.
[b] LSD at 5 per cent level was 0.25; at the 1 per cent level, 0.34.
[c] LSD at 5 per cent level was 0.44; at the 1 per cent level, 0.60.
[d] LSD at 5 per cent level was 0.24; at the 1 per cent level, 0.32.
[e] LSD at 5 per cent level was 0.17; at the 1 per cent level, 0.23.

Because of the effectiveness of the Tween sprays in depressing symptom development of bacterial wilt, several other surface-active materials were tested (Table 2). These materials were tested once each at concentrations of 1000 and 10,000 ppm.

Symptoms on plants sprayed with Triton X-155 at 10,000 ppm were markedly less severe than those on unsprayed plants. Spraying with Triton X-114 at 1000 ppm also resulted in significantly milder symptoms, but this material was severely phytotoxic at 10,000 ppm; it caused a water-soaking and softening at the base of the culm, with resultant lodging. This effect was evident the day following application of the sprays. There was no injury at 1000 ppm. Solutions of Ivory Flakes and of Dreft at 10,000 ppm decreased the development of bacterial wilt. Silver Dust was not effective at either concentration. Dreft at 10,000 ppm caused a slight softening at the base of the plants.

Further studies with antibiotics and Tween 20.—The effects of a moist atmosphere and of the addition of glycerol to the spray formulation on the efficacy of streptomycin, terramycin, and Tween 20 in reducing wilt development were studied. Sprays of 50 and of 500 ppm streptomycin or terramycin, and of 10,000 ppm Tween 20, were applied to 3 groups of plants. One set was placed in a moist chamber for 24 hours immediately after spraying. The second set remained on the greenhouse bench throughout the experiment. The third set received the spray materials to which had been added 10,000 ppm glycerol; these plants remained on the greenhouse bench. The addition of glycerol to antibiotic sprays has been reported to enhance penetration of some antibiotics into plant tissues and to improve control of some bacterial diseases (2,3).

Disease indices of untreated plants in the 3 sets did not differ significantly (Table 3). As in previous experiments, 500 ppm streptomycin did not affect bacterial wilt development under ordinary greenhouse conditions. When plants were placed in the moist chamber for 24 hours after spraying with 500 ppm streptomycin, however, severity of wilt symptoms was less on such plants than on unsprayed controls. Terramycin at 50 and at 500 ppm reduced disease development in plants left on the greenhouse bench. Disease indices were still less for plants sprayed with 500 ppm terramycin and then placed in the moist chamber for 24 hours before inoculation. Tween 20 reduced disease development. The effect of this treatment was unaffected by atmospheric moisture. The addition of glycerol to streptomycin, terramycin, or Tween 20 sprays did not affect degree of wilt control by these materials; nor did glycerol alone have any effect on disease development. The placing of plants in a moist chamber or the addition of glycerol to the spray formulation did not appear to influence the phytotoxicity of the higher concentrations of streptomycin, terramycin, or Tween 20.

Results of this experiment indicate that conditions of high atmospheric moisture may enhance control of bacterial wilt of sweet corn by streptomycin and terramycin.

To study the effects of coverage on the efficacy of Tween 20, experiments were conducted in which different parts of corn plants were treated. One per cent Tween 20 was applied 1) to the entire foliage, 2) to the dorsal leaf surfaces, 3) to the dorsal leaf surfaces with exception of the "whorl," 4) to the "whorl" (filled to capacity), and 5) to the soil (5 ml). Results in Table 4 are representative of those from 4 similar experiments.

Foliage applications of Tween 20 were always effective in reducing bacterial wilt development. Soil applications were never effective. Disease control was greater on plants sprayed over-all or on the dorsal leaf surfaces only than that on plants sprayed over-all except for the "whorl" or those given "whorl" applications only. Maximum bacterial wilt control, then, was dependent on application both to the expanded

TABLE 3.—*Severity of bacterial wilt in sweet corn plants that prior to inoculation were sprayed with streptomycin, terramycin, or Tween 20, with or without glycerol, then placed in the greenhouse, and in plants that were sprayed without glycerol and then placed in a moist chamber*

Treatment	Concentration, ppm	Disease index[a] of plants subjected to indicated conditions: Greenhouse, Glycerol in spray	Greenhouse, No glycerol	Moist chamber
Streptomycin	50	0.96	0.89	0.68
Streptomycin	500	0.76	0.88	0.57
Terramycin	50	0.68	0.54	0.41
Terramycin	500	0.62	0.51	0.14
Tween 20	10,000	0.23	0.23	0.19
No treatment		0.88	0.99	0.86

[a] Three leaves on each plant were assigned a rating of 0 to 5, where 0 represented a healthy and 5 a dead leaf. Mean ratings for plants were used to calculate pot means the average of which served as disease indices. LSD at the 5 per cent level was 0.26; at the 1 per cent level, 0.34.

TABLE 4.—*Severity of bacterial wilt in sweet corn plants covered prior to inoculation to different degrees by sprays containing Tween 20*

Parts sprayed	Disease index[a] of plants sprayed with indicated concentration: 1,000 ppm	3,000 ppm	10,000 ppm
None			0.90
All foliage			0.19
Dorsal leaf surfaces			0.24
Dorsal leaf surfaces less whorl			0.62
Whorl only	0.55	0.39	0.47
Soil only			0.72

[a] Three leaves on each plant were assigned a rating of 0 to 5, where 0 represented a healthy and 5 a dead leaf. Mean ratings for plants were used to calculate pot means the averages of which served as disease indices. LSD at the 5 per cent level was 0.19; at the 1 per cent level, 0.25.

leaf blades and to the "whorl." There were no statistically significant differences between disease indices of plants sprayed on the dorsal surfaces and those sprayed over the entire foliage. There were usually no differences in the degree of control obtained by "whorl" applications of 1000 and 10,000 ppm of Tween 20.

To obtain an indication of the length of time an application of Tween 20 might be effective in suppressing wilt development, plants were inoculated at intervals of 1, 2, 4, and 7 days following application of 10,000-ppm Tween 20 sprays. The effectiveness of the material decreased rapidly with the increasing time interval. Maximum effect on disease development resulted when plants were inoculated 1 day after spraying. Statistically significant (5 per cent level) effect on symptoms was obtained after an interval of 2 or 4 days, whereas the disease index of plants inoculated 7 days after spraying was almost identical with that of the unsprayed control plants.

The toxicity of successive applications of Tween 20 to sweet corn plants was measured by weighing aboveground parts of plants sprayed at intervals of 4 days with 1, 2, 3, and 4 applications of 10,000 ppm Tween 20. Fresh weights of corn plants were progressively less as the number of applications was increased. In 2 tests, the fresh weight of plants receiving 4 sprays was 75 and 78 per cent that of the control plants.

The toxicity of Tween 20 to *B. stewartii* in culture was tested in a laboratory experiment. The bacterium was streaked on yeast-extract agar containing 30, 160, 800, 6000, 20,000, or 100,000 ppm Tween 20. Growth of the bacterium was not inhibited at any of the concentrations tested.

Discussion.—Systemic action possibly was involved in the reduction of the development of bacterial wilt symptoms by antibiotics and by wetting agents. Tween 20 and terramycin, but not streptomycin, reduced wilt development when plants were sprayed 24 hours before inoculation by hypodermic injection at the base of the culm. When plants were placed in a moist chamber for 24 hours after spraying, control also was obtained with streptomycin, and control by terramycin was enhanced. The control obtained by inserting the pathogen into sprayed plants, and the increased control obtained by placing sprayed plants in a moist atmosphere, can be interpreted on the basis of absorption of the materials by the corn plants. There is other evidence that antibiotics are absorbed through plant leaves. Disks from leaves of *Sedum purpureum* (L.) Link that were sprayed with 1000 ppm streptomycin carried in 1000 ppm Tween 20 absorbed more of the antibiotic when the disks were placed in a humid than in a dry atmosphere[3]. The addition of various hygroscopic agents to antibiotic sprays increased the amount of streptomycin and some other antibiotics absorbed by plant leaves and increased their effectiveness (3). Systemic action also was indicated in the control of bacterial wilt of cucumber by sprays of terramycin or streptomycin (11).

It is possible that test materials might have filtered down between the unexpanded leaves in the "whorl" to the level at which inoculation would be made and thereby come in contact with the inoculum. That this would account for control seems unlikely however. Streptomycin, for example, will inhibit *B. stewartii* in culture at concentrations as low as 10 ppm (7), but this antibiotic was completely ineffective at 500 ppm in reducing bacterial wilt development in routine greenhouse tests. Tween 20 was nontoxic to *B. stewartii* at concentrations of 100,000 ppm (10 per cent) in agar but consistently reduced symptom development. This compound presumably acted by entering the plant tissues and modifying, in some way, the susceptibility of the host.

It is significant that 8 of the 9 surface-active agents tested reduced severity of bacterial wilt symptoms. To the knowledge of the writers, no reports of control of vascular plant diseases by the use of surface-active agents have been made. In the case of Tween 20, at least, the material was also nontoxic to the pathogen in culture. Although phytotoxic effects were observed with most of these materials in the greenhouse tests, it is possible that nonphytotoxic surface-active agents effective against bacterial wilt and other diseases may be found.

In tests with mixtures of antibiotics and wetting agents for the control of plant diseases, the effect of the wetting agent alone also should be determined.

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A BACTERIAL DISEASE OF CLOVER AND VELVET BEANS[1]

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SUMMARY

A bacterial leaf spot of white clover was observed in numerous areas in the lawn of Cornell University campus during the summer of 1954. The bacterial pathogen was isolated and proved to be pathogenic on white clover, Ladino clover, red clover, Red Kidney bean, velvet bean, and lespedeza. Alfalfa, cowpea, crotalaria, hyacinth bean, kudzu vine, lupine, sesbania, sieva bean, and soybean were immune. The pathogen was studied in culture and determined to be *Pseudomonas stizolobii* (Wolf) Stapp.

During the summer of 1954, numerous areas were observed in the lawn of the Cornell University campus where the leaves of the white clover (*Trifolium repens* L.) were spotted and dying. The lesions were necrotic and dark brown in color; in early stages, there was a water-soaked margin around the spots on the underneath surface of the leaflets. Eventually the entire leaflet was involved and died. Dark areas also were noticed on the stipules. Aside from these symptoms, there were no pronounced characteristics of the disease. Microscopic examinations of the lesions revealed an abundance of bacteria. The possibility arose that *Pseudomonas syringae* v. Hall was the cause of the disease. Lilac bushes are numerous on the campus, and the blight frequently has been observed upon them. Furthermore, white clover is a suscept of this pathogen.

A number of isolations were made from the infected clover leaflets, and in all instances a slow-growing white bacterium arose on the plates. The bacterium did not, however, have the appearance of *P. syringae*. Inoculations were made with these recently isolated bacteria on healthy white clover plants in the greenhouse, and lesions typical of those found on diseased plants in the lawn appeared within approximately 2 weeks.

The following summer (1955) was very hot and dry, and only occasionally was a diseased clover plant found. Its presence, however, was an indication that the pathogen could overwinter, probably on the dead clover plants.

To determine the host range of this bacterial pathogen, and to ascertain whether or not the disease had been previously described, inoculation experiments were made on 14 different leguminous plants. These experiments were conducted on both leaves and stems. The methods were as follows. Water dilutions of 48-hour-old bacteria grown on nutrient agar slants were swabbed with cotton over leaves that had been pricked with insect needles. Both the upper and lower surface of the leaves were so treated. Stems were stabbed with a sharp-pointed scalpel that had been contaminated with the pathogen.

Six species and varieties of plants proved to be susceptible. These were as follows: white clover (*Trifolium repens* L.) including Ladino clover; red clover (*Trifolium pratense* L.); Red Kidney bean (*Phaseolus vulgaris* L.); velvet bean (*Stizolobium Deeringianum* Bort.); and lespedeza (*Lespedeza* sp.). On white and Ladino clovers, the lesions were similar in appearance to those found naturally on the campus. On red clover, spots were larger than those on white clover and had yellow margins. Death of the leaflet occurred above such lesions (Fig. 1). On Red Kidney bean leaves, lesions were very slow in developing and appeared like small spots caused by *Xanthomonas phaseoli* (E. F. Sm.) Dows. No infection occurred on the stem and only slight infection on the pods. The slowness in development and the smallness of the lesions indicated that the disease may never become serious on the bean plant. The infection on lespedeza leaves was similar to that on white clover. A great many small necrotic lesions appeared on inoculated leaves of the velvet bean (Fig. 1). Their appearance was similar to that pictured by Wolf (5) for infection with *Pseudomonas stizolobii* (Wolf) Stapp, but the spots were not as angular. From the above inoculation experiments, the velvet bean appeared to be very susceptible.

No infection was obtained on leaves or stems of the following plants: alfafa (*Medicago sativa* L.), cowpea (*Vigna sinensis* Savi), crotalaria (*Crotalaria mucronata* Desv.), hyacinth bean (*Dolichos lablab* L.), kudzu vines (*Pueraria thumbergiana* Benth.), lupine

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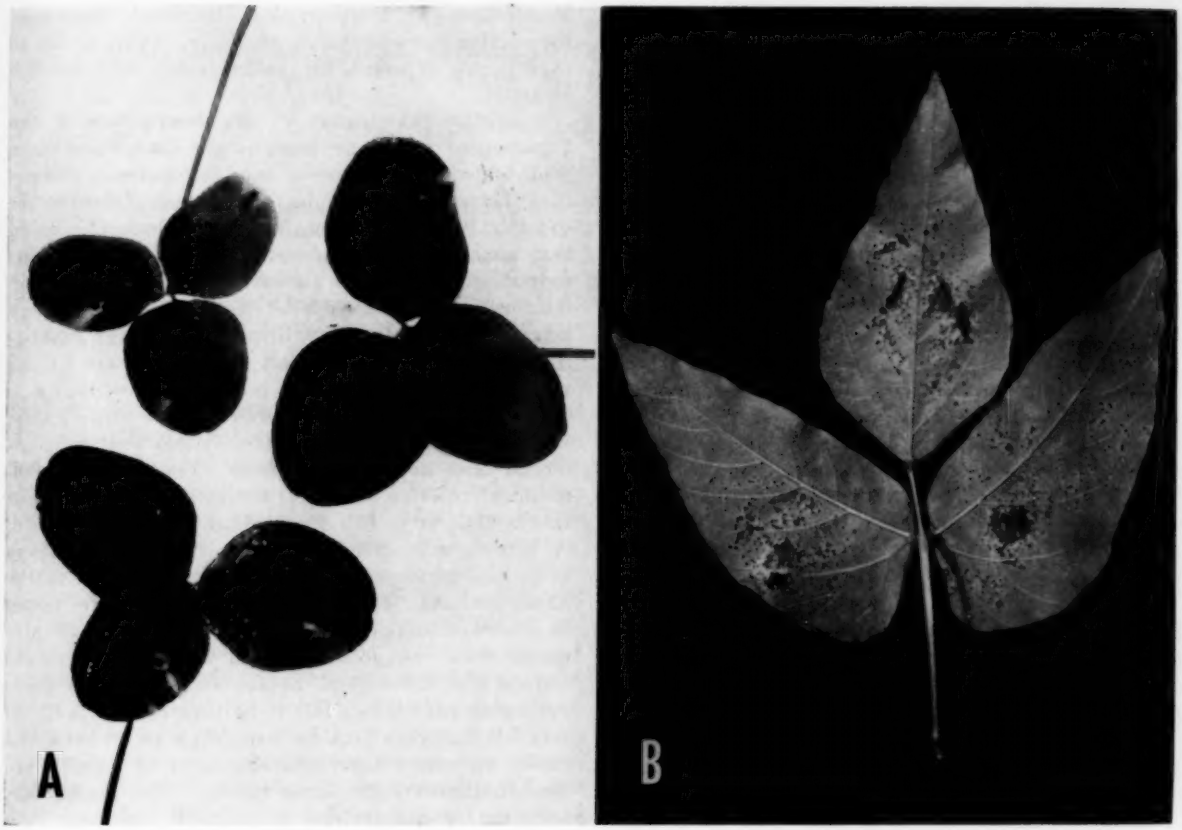

FIG. 1. Bacterial leaf spots caused by *P. stizolobii* (Artificial inoculation). A) On red clover. B) Early stages on velvet bean.

(*Lupinus albus* L.), sesbania (*Sesbania* sp.) sieva bean (*Phaseolus lunatus* L.), and soy bean (*Glycine max* Merr.).

The pathogen.—The following description of the bacterial pathogen was based on a study of 7 isolates. Five of these were isolates from naturally infected white clover leaves. The other 2 were reisolates from velvet bean and from red clover. The methods used in their study were those described in the Manual of Methods for Pure Culture Study (2). The reactions of all 7 isolates were identical.

Morphology.—The bacteria are non-spore-forming rods, slender with rounded or pointed ends, occurring singly or in pairs. Cells from 24-hour cultures on beef-extract-peptone agar average 2.3 (1.3–4.0) × 0.75μ. When 1 per cent glucose is added to the above medium, filaments are formed. The bacteria are Gram-negative but are not actively motile. Observation with the phase microscope on 3 isolates left one in doubt as to their motility; however, staining with the Plimmer and Paine modification of the Casares-Gils flagella stain or with the Fisher and Conn modication of the Bailey method demonstrated in 24-hour cultures a few cells with a single short polar flagellum.

Cultural characteristics.—On beef-extract-peptone agar at 27°C, growth in 48 hours is light to moderate, colorless, and filiform. Early growth is butyrous, but later it becomes hard and difficult to remove with a needle. On the above agar plus 1 per cent glucose, growth is moderate to good in 24 hours, white to cream in color, and slimy in consistency. On potato glucose agar, growth is moderate, light buff, and butyrous. Broth in 24 hours is lightly turbid with little or no further clouding. In litmus milk, the litmus is slowly reduced and later becomes purple, but the milk remains unchanged in consistency. A white and light turbidity develops in Fermi's, Uschinsky's, or Clara's solutions. There is a moderate growth on Krumwiede's triple-sugar agar, but the medium remains red. Growth on Endo's agar is pink, and there is no color change in the medium. A light pinkish filamentous growth occurs on desoxycholate agar slants. No green fluorescent pigment has been observed in any of the media used.

Physiological characteristics.—Gelatin is not liquified. Nitrites are produced from nitrates, but the reaction is stronger in a synthetic solution than in broth. No action on fat is detectable on Starr's spirit blue agar. A very slight H_2S production is observed at times on lead acetate paper suspended over tryp-

tone broth. Growth does not occur in a synthetic solution with ammonium salts as the nitrogen source, but a fair growth occurs in a synthetic nitrate solution with a suitable carbon source. The methyl red test is negative, and acetylmethylcarbinol is not produced. Catalase production is light. Growth occurs in 2 per cent NaCl in broth, but there is no growth in 4 per cent NaCl in broth. In shake cultures of a beef-extract-peptone agar plus 1 per cent glucose, the pathogen is a strict aerobe. Growth is slight at 6°-9°C. Optimum temperature is 27°-30°C and maximum approximately 37°C.

Acid is produced in an Ayres, Rupp, and Johnson's synthetic solution (to which a small amount of peptone has been added) containing glucose, fructose, or arabinose. There is slight acid with glycerol or xylose. No acid is formed with lactose, maltose, sucrose, dulcitol, etnanol, or salicin. A synthetic nitrate solution to which sodium citrate, malonate, hippurate, or tartrate has been added supports growth only when the citric salt is used. Starch is not hydrolysed, nor is a pectate medium liquified. Urease is produced.

Taxonomy.—Three nonchromogenic bacteria have been described as pathogenic on species of clover (3), and these should be considered in an attempt to determine whether or not the species under study is new or is a previously described bacterium. The 3 clover pathogens are *Bacillus trifolii* Vogl. (5), *Pseudomonas syringae* (3), and *P. stizolobii* (6). The first of these, although insufficiently described, is a spore former and so may be disregarded. The second, *P. syringae*, varies greatly from the clover pathogen in that it is a typical green fluorescent bacterium that grows well with ammonium salts and liquifies gelatin rapidly. *P. stizolobii*, which Wolf (6) described as the cause of a leaf spot of velvet beans in North Carolina, appears to be the same bacterial species as the clover pathogen. This conclusion is reached from the following facts. Wolf stated that his pathogen could infect velvet bean leaves but not soybeans, the only 2 plant species he tested for susceptibility. According to Miss Elliott (3), however, Miss McCulloch found that the species was pathogenic on clover. Thus, as far as experiments reported, the pathogenicity data are the same.

A careful examination of the descriptions of the 2 pathogens in culture leads to the same conclusion. Wolf stated that the velvet bean organism is nonmotile. He originally applied the name *Aplanobacter stizolobii*. Later, however, Miss McCulloch (4) found that young cells had a short polar flagellum. The writer's experience was similar, in that the clover bacterium first was considered nonmotile but later a single polar flagellum was demonstrated. The description of *P. stizolobii* by Wolf is not complete by the present standards, but there is little to show that it is different from the clover pathogen. The size of cells is somewhat different, and Wolf states that his bacterium does not reduce nitrates. Tests for this biochemical reaction, however, frequently show different results that vary with the medium and method used. A further difference is that Wolf states that there is no acid produced from the sugars he added to the basal medium. The carbon compounds were tested in a beef-extract-peptone broth, where the alkali produced from the peptone would neutralize any acid formed from the sugars. Experiments with other plant pathogens have shown this to be true (1). It is therefore felt that since both bacteria infect velvet bean and clover and since their characteristics in culture are similar, they are the same species. The present description is given since it is more complete than Wolf's account, and since it can be more readily checked in the future.

One point of interest that arises is the fact that since 1920, when Wolf described the pathogen, it has been reported only twice, and both times from Brazil. These reports are listed by Miss Elliott (3), and the writer has been unable to find other references to the disease or pathogen. Numerous leaf spots of clover have gone uninvestigated and it is conceivable that the pathogen has existed on this host during these years.

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AN ORANGE-COLORED STRAIN OF CORYNEBACTERIUM FLACCUMFACIENS CAUSING BEAN WILT[1]

M. L. Schuster and D. W. Christiansen[2]

SUMMARY

Presence of an orange-colored bacterium under the seed coat of beans grown in western Nebraska was manifested by a similar coloration of the seed. Seed infection and wilting of bean plants was obtained by hypodermic inoculations and by soil infestation with this bacterium. Physiological and morphological characteristics as well as pathogenicity tests indicate close similarities between isolates of this organism and *Corynebacterium flaccumfaciens*. It is designated by the name *Corynebacterium flaccumfaciens* var. *aurantiacum* n. var.

Orange-colored bacteria causing serious diseases of field crops are rare; however, diseases of ornamentals caused by these types of organisms have been described. *Corynebacterium fascians* Tilford (6), which causes a fasciation of sweet peas (*Lathyrus odoratus* L.), produces cadmium-yellow, deep-chrome, or orange-buff colonies on potato-dextrose agar; *Corynebacterium poinsettiae* Starr & Pirone (5), pathogenic on poinsettia (*Euphorbia pulcherrima* Willd.), appears salmon or flesh colored on the same type of medium. Isolations from orange-colored bean seed from western Nebraska yielded similarly colored bacteria. Because bacteria of this coloration are not described as causing a bean disease, investigations made during 1952-1955 included a determination of the prevalence of the disease and of the morphological and physiological characteristics and pathogenicity of these bacteria.

DETERMINATION OF AMOUNT OF ORANGE-COLORED SEED.—Orange-colored seed was first noted in 1952 in samples of dry field beans (*Phaseolus vulgaris* L.) of the Great Northern and Pinto varieties grown in western Nebraska (4). In a sample from Bridgeport, Nebraska, 30 per cent of the visibly affected seed (yellow and orange) were orange colored. A more nearly accurate determination was made of the actual amount of this type of seed in 1952 field-run beans from Gering and Mitchell areas. Of the seed culls discarded by the commercial photoelectric sorting machine at Gering, 0.83 per cent were orange colored. This represented 0.03 per cent of the field-run beans (Table 1). In 1948, samples of infected seed did not contain any orange-colored seed, an indication of the possible recent origin or appearance of the orange bacterium.

The amount of orange-colored seed was determined for the years 1953, 1954, and 1955. Seed was sampled at the bean elevators by means of a grain probe. Weight of individual samples ranged from 420 to 810 g. In 1953, lots from 6 farms were sampled from the Mitchell area; in 1954, 37 were samples from the Gering and Mitchell areas; and in 1955, 15 sample lots were obtained from the Gering area.

The orange-colored seed represented 0.8, 0.47, and 0.55 per cent of field-run beans for the years 1953, 1954, and 1955, respectively. These figures correspond to 8, 16, and 35 per cent, respectively, of the infected seed (Table 1). This indicates an increase of the orange strain in recent years. The percentages that were based on actual weights of seed would be low, because infected seed may be shrivelled and lighter in weight. Inasmuch as the infection percentages represent only seed that showed macroscopic symptoms of infection, the actual percentage of infected seed may not be as low as indicated.

PATHOGENICITY TESTS.—The color of bacterial isolates from the orange-colored bean seed was similar to the color of the discolored bean. These bacteria usually were found under the seed coat, in a manner similar to that reported for *C. flaccumfaciens* (Hedges) Dows. (2), although they also occur superficially on the seed coat.

Pathogenicity of the isolates was determined by inoculation of the following plant parts: 1) seed, 2) stem, and 3) leaf. The concentration of inocula was about 1 million bacterial cells per ml for these tests; cultures 48 hours old were used. Seed infection as evidenced by an orange color resulted most commonly from hypodermic injection of nodes to which pedicels of developing pods were attached. Of such inoculations of 65 plants, 75 per cent resulted in pods with one or more seed visibly infected.

Hypodermic inoculation of the lower part of the stem produced wilt symptoms, but visible infection of seed was not common. Of 8 plants inoculated in the second node, 6 showed wilt symptoms, and 8 of 50 seed examined were visibly affected. Comparable tests with *C. flaccumfaciens* produced 10 of 57 seed infected. Hypodermic inoculation into the first and second internodes of the stem, watersoaking of primary leaves, and inoculation of leaf petioles did not result in seed infection. Rubbing of the ventral suture of developing pods with a cotton swab previously

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TABLE 1.—*Percentage of seed infected with orange-colored bacteria from field beans grown in western Nebraska*

No. of farmers' lots	Year	Location	Total weight of sample	Percentage of seed infected		Percentage of infected seed with orange bacteria
				Orange	Yellow	
Bulk[a]	1952	Gering	6,765	0.03	0.30	10.0
6	1953	Mitchell	3,949	0.80	9.17	8.0
17	1954	Gering	13,196	0.33	3.16	9.4
20	1954	Mitchell	12,997	0.60	2.15	21.8
15	1955	Gering	8,944	0.55	1.01	35.3

[a] Represents samples from bulk storage at elevator.

dipped in a suspension of bacteria resulted in 7 of 39 seed infected. No infections resulted from similar inoculations on the sides of the pods.

Attempts to create wilt symptoms by application of a bacterial suspension to the soil produced diverse effects, depending on whether sterilized or nonsterilized soil was used. No visible seed infection of 102 seed examined from 7 plants resulted when sterilized soil was infested with the bacterium, whereas similar infestation of nonsterilized soil resulted in visible infection of 18 of 108 seed from 12 plants. In this experiment, the plants were supported by stakes placed outside the pots to avoid possible damage to the roots. Undoubtedly, natural wounding did occur because of the breaking through of secondary roots, but such injuries appeared insufficient as portals of entry for the organism.

Germination of orange-colored seed was variable. In potted soil, 3 per cent of 250 orange-colored seed germinated. Forty-nine per cent of an equal number of infected seed germinated in a ragdoll germinator. Apparently conditions for survival of seedlings from infected seed were less favorable in soil than in the ragdoll. Plants from visibly infected seed did not produce seed, as they usually died before reaching maturity.

Host-range studies determined the reaction of certain legumes to the bacterial isolates. Inoculation of scarlet runner bean (*Phaseolus coccineus* L.), tepary bean (*P. acutifolious* L.), soybean (*Glycine max* (L.) Merr.), and Alaska peas (*Pisum sativum* L.) was accomplished by hypodermic injection into the stems. An orange-colored bacterium corresponding in appearance and morphology to the one injected was recovered after 5 weeks from the soybeans and scarlet runner beans and after 8 weeks from the tepary beans, whereas none was obtained from the noninoculated controls. Only the scarlet runner beans showed the typical wilted condition associated with plants infected with *C. flaccumfaciens*. The reisolates were not tested for pathogenicity on field beans.

MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OF THE ORANGE BACTERIUM.—The organism is a gram-positive, short rod, and its size falls within the range of *C. flaccumfaciens*. Its motility was determined by the hanging-drop method. Best growth in culture is between 20° and 30°C; differences in growth at these temperatures were not apparent in agar. The organism makes slow growth at 5° and at 35°C, the 2 extremes of temperature employed. An interesting aspect is its variation in color when grown on 2 per cent potato-dextrose agar under different temperatures. The organism exhibited the following variations in color: orange chrome at 5° and 10°C, salmon orange at 15° and 30°, bittersweet orange at 20° and 25°, and orange buff at 35°. Colors were determined by the use of Ridgway's color standards (3). The specific factor(s) that governs this variation in color expression has not been investigated.

Physiological tests as listed in Bergey's Manual (1) for *C. flaccumfaciens* were repeated for the orange bacterium; the results indicate that the orange-colored organism cannot be distinguished on this basis from *C. flaccumfaciens*, the yellow-colored bean wilt bacterium. Furthermore, Moorhead[4] made serological cross reactions, the results of which will be published elsewhere, and found that the orange strain is similar serologically to the yellow-colored bean wilt organism but not to *Xanthomonas phaseoli* (E. F. Sm.) Dows.

The orange color of bean seed infected with this new strain aids in differentiating seed from those infected with the common blight organism, *X. phaseoli*, or with the yellow bean wilt bacterium, both of which are found in beans grown in western Nebraska.

It is felt that the differences between the stable orange strain and the yellow bean wilt organism are probably varietal and not specific. Therefore it is designated by the name *Corynebacterium flaccumfaciens* var. *aurantiacum* n. var.

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FUNCTION AND LONGEVITY OF CLEISTOTHECIA OF ERYSIPHE GRAMINIS F. SP. HORDEI [1]

J. G. Moseman and H. R. Powers, Jr.[2]

SUMMARY

Cleistothecia of *Erysiphe graminis* DC. f. sp. *hordei* Em. Marchal formed on winter barley in North Carolina during the springs of 1952 and 1954 erupted and discharged their ascospores during the summer following periods of cool, moist weather. No infections were observed on volunteer seedlings following the discharge of ascospores.

Formation of ascospores in cleistothecia collected from plants growing in the field was more rapid when the cleistothecia were submerged in water than when they were kept in a moist atmosphere. Both treatments were equally effective in inducing ascospore discharge. Alternate wetting and drying, or cooling and warming, did not improve either the rate of formation of ascospores or their discharge. The minimum and optimum temperatures for the discharge and germination of ascospores were 8° and 16°–20°C, respectively. The maximum temperature for the discharge of ascospores was 24°, and for the germination, 28°C. Ascospores were formed and discharged when cleistothecia were moistened, or submerged in water, at low temperatures and then dried at high temperatures but not when they were moistened or submerged at high temperatures and dried at low temperatures.

Infections were obtained with ascospores derived from cleistothecia in mycelial mats on dried leaves that had been stored for over 13 years in a refrigerator at 10°C. Preservation of cultures of *E. graminis* in the form of cleistothecia is proposed.

Methods for maintaining cultures of obligate parasites of cereal crops have received considerable attention in recent years. Progress has been made in storing the urediospores of the rust organisms on cereals by lyophilization and other methods. Most of these techniques are not applicable with the conidia of *Erysiphe graminis* that are thin walled and have an unusually high water content. Since preservation of conidia of *E. graminis* is difficult, the use of the cleistothecia and ascospores should be investigated. The possibility of maintaining cultures of this organism as cleistothecia depends on the function and longevity of the cleistothecia, and on the formation, discharge, and germination of ascospores in the laboratory. This study was designed to determine 1) the role of cleistothecia in overseasoning; 2) the factors influencing formation, discharge, and germination of the ascospores; and 3) the viability of cleistothecia after long periods of storage.

The function of cleistothecia in the survival from season to season of *E. graminis* f. sp. *hordei* has not been studied very extensively. Foster and Henry (2) suggested that in Alberta, Canada, the fungus overwinters as cleistothecia. They found that conidia formed in the fall lost their viability during the winter, but that cleistothecia formed in the fall remained on the plants and developed ascospores just prior to the initial infections in the spring. Cherewick (1) observed that under field conditions at Winnipeg, Canada, cleistothecia formed during the summer matured and discharged their ascospores in the fall following periods of wet, mild weather.

The formation of ascospores from undifferentiated protoplasm in cleistothecia and their discharge has interested scientists for many years. As early as 1874 Wolff (7) reported that cleistothecia, in which ascospores had not been differentiated, would release ascospores when submerged in water for 5–8 days. In 1903, Salmon (6) and Marchal (4) reported infection studies on cleistothecial material. Graf-Marin (3) compared the effect on the formation and discharge of ascospores of keeping cleistothecia at various moistures

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and temperatures. The best results were obtained when the cleistothecia were either submerged at 9°C for 12 hours and then kept at 21° or when kept continuously submerged at 21°C. Cherewick (1) found that alternate drying and wetting, with chilling, were essential for the formation of ascospores in cleistothecia collected from plants growing in the greenhouse.

Cherewick (1) reported that cleistothecia on wheat and barley were still viable after storage for 2 years at room temperature, in a refrigerator, or at alternating temperatures. He found also (personal correspondence) that cleistothecia collected from plants growing in the field were viable after being stored at room temperature for 7–8 years.

MATERIALS AND METHODS.—Observations on the oversummering of cleistothecia of *Erysiphe graminis* DC. f. sp. *hordei* Em. Marchal in the field were made in the winter barley disease nursery near Raleigh, North Carolina, in the summer of 1952 and again in 1954. The term "oversummering" is used, since summer is the only season in North Carolina in which there is no barley in the fields, with the exception of a few volunteer plants. Cleistothecia collected in the spring from severely infected plants were examined under a low-power microscope to determine whether ascospores had been formed or discharged.

Cleistothecia used to study ascospore formation, discharge, and germination were collected from plants grown at Ottawa, Canada; Madison, Wisconsin; Beltsville, Maryland; and McCullers and Waynesville, North Carolina. These cleistothecia differed in maturity, which caused a variation in the time required for formation and discharge of ascospores. Two replications of 50 cleistothecia of each culture were included in each series of tests. The rate of ascospore formation and discharge was determined by examining 10 cleistothecia each day beginning with the fifth day of the experiment.

Cultures were obtained from cleistothecia of *E. graminis* f. sp. *hordei* by the following method. Cleistothecia were removed from the mycelial mats to reduce contamination with other organisms. To facilitate examination and manipulation of individual fruiting bodies, the cleistothecia were kept continuously moist on filter paper suspended over water in a Petri plate rather than submerged in water. When cultures from single ascospores were not required, the moist filter paper with 1 or more fruiting bodies was suspended at the top of a lamp chimney that inclosed seedlings of the variety Heil Hanna 3, C. I. 682[3], growing in 3-in. clay pots. The discharged ascospores fell on and infected the seedlings. When cultures from individual ascospores were desired, the spores were discharged on 2 per cent water agar in a Petri plate, and individual ascospores were transferred with a fine-pointed needle to seedlings under a lamp chimney. Infections were obtained from about 10 per cent of the spores thus transferred.

EXPERIMENTAL RESULTS.—*Function of cleistothecia in oversummering.*—During the summers of 1952 and 1954, cleistothecia of *E. graminis* f. sp. *hordei* were collected at 2-week intervals, beginning about June 1. Ascospores had been formed in most of the cleistothecia at the time of the first collections. Some of the cleistothecia had already erupted in the collections made on July 4, 1952, and on July 7, 1954. Both of these collections were made following periods during which there had been numerous rains. All of the cleistothecia had erupted in the collections made on July 18, 1952, and on July 24, 1854. Volunteer plants in the field at this time did not show infection, and no infections were observed even when these plants were transplanted and grown under artificial lights at a temperature of 18°C. In fact, no infection appeared in the barley nurseries during those 2 summers. From these results, it appears unlikely that the cleistothecia play an important role in the maintenance of the organism through the summer period at Raleigh, North Carolina.

The effect of temperature and moisture on the formation, discharge, and germination of ascospores.—Cleistothecia from plants grown at 5 locations in North America were used to study the effect of temperature and moisture on the formation, discharge, and germination of ascospores. The time required for the maturation and discharge of ascospores depended on the stage of development of the cleistothecia. Cleistothecia from plants grown at all 5 locations responded similarly to the various combinations of moisture conditions and temperatures.

In the study of the formation and discharge of ascospores from cleistothecia kept at 16°C, use was made of the following combinations of moisture conditions: 1) submerging in water on the bottom of a Petri plate; 2) maintaining on moist filter paper suspended over water in a Petri plate so as to maintain a nearly saturated atmosphere; 3) submerging for 16 hours, drying for 8 hours, followed by continuous submerging; 4) moistening for 16 hours, drying for 8 hours, followed by continuous moist conditions; 5) alternate submerging and drying for 3 days followed by continuous submerging; and 6) alternate moistening and drying for 3 days followed by continuous moistening.

The results from this study are shown in Table 1. After 6 days, cleistothecia with undifferentiated protoplasm had formed and discharged more ascospores when they were submerged in water than when merely kept moist. The percentage of those that discharged ascospores after 9 days was less when they were kept continuously submerged or moist than when submerged or moistened, dried, then resubmerged or remoistened. From cleistothecia in which ascospores already had been formed, ascospores were discharged more rapidly when they were kept continuously submerged or moist than when they were alternately submerged or moistened and dried. After 9 days, however, the

[3] C. I. refers to the accession number of the Cereal Crops Section.

TABLE 1.—*Formation and discharge of ascospores from cleistothecia of Erysiphe graminis f. sp. hordei at 16°C in various combinations of moisture conditions*

Moisture condition	Percentages of cleistothecia discharging ascospores[a]			
	After 6 days		After 9 days	
	Culture A	Culture B	Culture A	Culture B
Continuously submerged	9	12	33	76
Continuously moist	6	20	28	70
Alternately submerged and dried 1 day then continuously submerged	21	6	46	64
Alternately moistened and dried 1 day then continuously moist	6	8	50	57
Alternately submerged and dried 3 days then continuously submerged	20	6	52	55
Alternately moistened and dried 3 days then continuously moist	10	8	46	50

[a] In culture A, the cleistothecia contained undifferentiated protoplasm; in culture B, most of the cleistothecia had ascospores formed.

percentage of cleistothecia that had discharged ascospores was nearly the same.

The cardinal temperatures for ascospore discharge and germination are shown in Table 2. The minimum temperature for the discharge and germination of ascospores was 8°C and the optimum was between 16° and 20°. The maximum temperatures at which ascospores were discharged and germinated were 24° and 28°, respectively. The maximum temperature for the discharge of ascospores might have been somewhat higher had not saprophytic organisms interfered with the experiments at 28° and 32°.

Interactions of moisture and temperature affected the formation and discharge of ascospores (Table 3). Ascospores were not formed nor discharged when cleistothecia were kept alternately moist at 24°C and dry at 8° or 12°, but they were formed and discharged when kept alternately moist at 8° or 12° and dry at 24°C. The latter set of conditions was more similar

TABLE 2.—*Ascospore discharge and germination when cleistothecia of Erysiphe graminis f. sp. hordei were kept at different temperatures*

Temperature °C	Ascospores discharged after indicated period		Percentage germination
	6 days	11 days	
5	None	None	
8	None	Few	35
12	None	Numerous	62
16	Few	Numerous	95
20	Few	Numerous	76
24	Few	Numerous	44
28	None	Saprophytes[a]	Few[b]
32	None	Saprophytes[a]	

[a] Saprophytes began growing on the cleistothecia. No ascospores were released.

[b] Spores discharged in the 16°C chamber for less than 4 hours continued to germinate at 28°C.

TABLE 3.—*Discharge of ascospores from cleistothecia of Erysiphe graminis f. sp. hordei that were kept at different temperatures under alternately moist and dry conditions*

Temperature while held under conditions indicated[a]		Ascospores discharged after indicated period	
Dry	Moist	7 Days	11 Days
°C	°C		
8	20	None	Few
8	24	None	None
12	20	None	Few
12	24	None	None
20	8	None	Numerous
20	12	Few	Numerous
24	8	None	Numerous
24	12	Few	Numerous

[a] Cleistothecia were moist for 16 hours and dry for 8 hours during each of the first 3 days. Then they were kept continuously moist.

than the former to that in which cleistothecia erupted naturally.

Longevity of cleistothecia.—Cleistothecia used in the longevity tests were furnished by Dr. W. J. Cherewick and were the same cultures that he used in studies reported in 1944 (1). Cultures were obtained from these cleistothecia by the technique described in the section on material and methods. Infection was obtained in October, 1955, from cleistothecia of race 10 collected from plants in the greenhouse in May, 1942. This material had been kept dry in a coin envelope in a refrigerator at 10°C during the 13 years. Cleistothecia of race 12 collected in 1946 also caused infection in October, 1955. Several other cleistothecial collections, which had been kept dry at 10° in a refrigerator since 1949 or 1950, also were found to be viable.

DISCUSSION.—The observation that cleistothecia that form on plants during the spring erupt during periods of cool, wet weather in early summer is in agreement with the results obtained in Canada (1, 2). Since no infections were observed in the field during the summer, the function of the cleistothecia in perpetuating the organism is not clear. They probably do not play an important role in the oversummering of the organism at Raleigh, North Carolina.

Temperatures from 8° to 24°C, at which ascospores are formed, discharged, and germinated, occur frequently in nature. The reproduction of this organism may be influenced by temperature, however, since ascospores were formed and discharged when the cleistothecia were kept dry at high temperatures and moist at low temperatures but not when they were kept dry at low temperatures and moist at high temperatures. Moisture conditions apparently are more critical, since ascospores were discharged only when moisture conditions were adequate, regardless of the temperature.

Cleistothecia may be a means of preserving cultures of races of *E. graminis*. It was found that cleistothecia were viable after over 13 years in storage. Since this organism is heterothallic (5), only cultures that are

compatible will combine. When possible the paired cultures should be pathogenically similar. In critical studies it may be advisable to use compatible cultures that are similar in pathogenicity and derived from the same cleistothecium.

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PHYTOPATHOLOGICAL NOTES

Respiratory Protective Devices for Agricultural Pesticides[1]. R. A. FULTON AND W. D. MCCLELLAN[2]. During the past several years, respirators for the protection of operators from dusts, mists, and low vapor concentrations of insecticides have been discussed in several releases, the most recent of which was issued by the Agricultural Research Service on June 27, 1955.[3] Recently, questions regarding the hazard of inhaling fungicides have resulted in the testing of respirators developed for protection against insecticides[4] against a number of types of fungicides and nematocides. These units have been found to be effective against fungicides and nematocides as well as insecticides.

The compounds tested were representative of 5 classes: CARBAMATES—zinc ethylenebis [dithiocarbamate] (zineb), ferric dimethyldithiocarbamate (ferbam), and sodium methyldithiocarbamate (Vapam); MERCURY COMPOUNDS—*N*-(ethylmercuri)-*p*-toluenesulfonanilide (Ceresan M) and cyano(methylmercuri) guanidine (Panogen); HALOGENATED HYDROCARBONS—pentachloronitrobenzene (Terrachlor), 1,3-dichloropropene; 1,2-dichloropropane (D-D), and 1,2-dibromoethane (ethylene dibromide); COPPER COMPOUNDS—calcium copper chloride ($4Cu(OH)_2 \cdot CaCl_2 \cdot 4H_2O$) (Copper A Compound); PHENOXY COMPOUNDS—sodium 2,4,5-trichlorophenoxide (Dowicide B).

The testing procedure was the same as described for insecticides[4]. Air samples were drawn at 10-minute intervals and analyzed according to published procedures.[5,6,7,8]

The respirator units that were found to give adequate protection, when used with proper care, against sprays, dusts, and low concentrations of vapor of all of the above-mentioned compounds are as follows: Respirator No. 5561, equipped with filter cartridge combination R-561 (American Optical Co., Southbridge, Mass.); Farm Spray Respirator No. CR-72183, equipped with cartridge No. CR-49293 and filter No. 73488 (Mine Safety Appliances Co., Pittsburgh, Pa.); All Vision Chemical Cartridge Respirator No. CR-74910, equipped with inner cartridge No. CR-73841 and outer cartridge No. 73927 (Mine Safety Appliances Co., Pittsburgh, Pa.); and Agritox Respirator, equipped with cartridge No. 11A and filter No. R490 (Willson Products Inc., Reading, Pa.).

[1] Contribution from the Agricultural Research Service, United States Department of Agriculture.

[2] Respectively, Chemist, Entomology Research Branch, and Pathologist, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

[3] Haller, H. L. 1955. Respiratory devices for protection against inhalation hazards of dusts, mists and low vapor concentration of certain insecticides. Agricultural Research Service, U. S. Dept. of Agr., June 27, 1955.

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[7] Fulton, R. A., R. H. Nelson, and F. F. Smith. 1950. The toxicity of lindane vapor to insects. Jour. Econ. Ent. 43: 223-224.

[8] McFarlane, W. D. 1932. Application of the sodium diethyldithiocarbamate reaction to the micro-colorimetric determination of copper in organic substances. Biochem. Jour. 26: 1022-1033.

All the respirators listed have 2 cartridge units attached to the facepiece.

The use of respirators is advised for protection from dusts or mists during field handling of the fungicides and nematocides mentioned and during exposure to them in open fields. Their use is not a substitute for essential precautions.

It is especially important that respirators be used when the fungicides and nematocides are being formulated and ground, when distribution equipment is being loaded or empty containers disposed, and when ever operators are exposed to obvious amounts of dusts or mists. Field operators who may be exposed to small amounts—even those not obviously detectable—continuously during the day or for successive days should use respirators faithfully as à precaution.

Respirators will give adequate protection to airplane pilots during normal dusting or spraying operations, but gas masks should be worn when concentrated material is being loaded. Pilots should wear goggles that give a tight seal with the respirator around the nose piece.

In the use of respirators, the following practices are highly important: 1) change filters twice a day, or oftener, if breathing becomes difficult; 2) change cartridges after 8 hours of actual use, or oftener, if any odor of the fungicide or nematocide is detected; 3) remove filters and cartridges and wash facepiece with soap or detergent and warm water after use, then, rinse thoroughly to remove all traces of the cleansing agent, dry facepiece with clean cloth that is uncontaminated with fungicide or nematocide, and place facepiece in a well ventilated area to dry; 4) store respirator, filters, and cartridges in a clean dry place, preferably in a tightly closed paper or plastic bag.

The respirator should be fitted properly on the face, not too high on the nose, with narrow portion over the bridge of the nose, and chin cup contacting under side of the chin. Headbands should be adjusted just tightly enough to insure a good seal. Manufacturers can supply special facepieces if the standard one does not fit.

Respirators do not provide needed protection from inhalation of all dust, mist, and vapors; their use is not advised for 1) those formulating or mixing fungicides or nematocides in closed or inadequately ventilated spaces, or 2) those applying the volatile fungicides and nematocides in greenhouses. Full-face gas masks equipped with tested canisters should be worn under these conditions. The gas-mask canisters that have been found to give adequate protection against all the fungicides and nematocides mentioned are as follows: Canister Type 2-OVAG or No. 15-OVAG-F Insecticide Canister (Acme Protection Equipment Company, 3037 W. Lake Street, Chicago, Ill.); Canister GMC-1 (Mine Safety Appliances Company, Pittsburgh, Pa.); Canister G3FD (Willson Products, Inc., Reading, Pa.); and universal-type canister of any manufacturer (Type N, bearing Bureau of Mines approval).

The gas mask should be worn with proper protective clothing when fungicides or nematocides are applied in greenhouses or other enclosed spaces.

For the continuous handling of fungicides or nematocides, it has been found to be good practice to change clothing daily. Wash hands before eating, and shower or bathe at the end of the working day.—Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland.

A Hyaline Variant of Verticillium albo-atrum Pathogenic to Tomato Plants. GEORGE F. PEGG. In experiments on tomato plants with *Verticillium albo-atrum* Reinke & Berth., a strain of this fungus with hyaline mycelium was isolated from a wilting tomato plant. It did not produce the typical, dark, torulose hyphae described by Reinke and Berthold[1] and by Berkeley and Jackson[2]. Sectors of an apparently identical strain also arose from a normal greyish-black culture of *V. albo-atrum* that had been isolated from the same host and grown on Difco prune agar.

Single-spore isolations from the original isolate and from the hyaline sectors produced a white, floccose mat of aerial and sub-aerial hyphae. On 5 per cent maize-meal agar containing 3 per cent sucrose, the aerial hyphae were aggregated into mycelial ropes or coremia. At first the coremia were white and woolly, but after several weeks' growth at 21°C the culture took on a flat, translucent appearance, particularly towards the centre. Each mycelial strand (Fig. 1, A) consisted of from 5 to many intertwined hyphae, often up to several mm in length. Individual hyphae of the strand grew out at right angles to form simple or verticillate conidiophores (Fig. 1, A, B) bearing slimy, spherical heads of spores. The lengths of the conidiophores were extremely variable, but the size of the phialides was about 16μ–40μ × 1μ–1.5μ. Like the conidiophores, the conidia were variable and appeared to be of 2 kinds: the normal, simple, ovocylindrical type measuring 3μ–9μ × 1.5μ–4.5μ and the larger distorted spores that were sometimes 2-celled. Only a few of the latter type were observed, and these were more numerous in the older cultures than in younger ones. On germination, a single germ tube was produced from the end of each cell (Fig. 1, C). When first isolated, the fungus was capable of forming mycelial ropes on a variety of media; they are formed best, however, on 5 per cent maize-meal agar. In liquid Czapek's medium and on nutrient agar, the growth rate of the hyaline variant was much higher than that of the normal strain of *V. albo-atrum;* on exposure to daylight, a pigment was produced that imparted a

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[2] Berkeley, G. H., and A. B. Jackson. 1926. Verticillium wilt of the red raspberry. Sci. Agr. 6: 261-270.

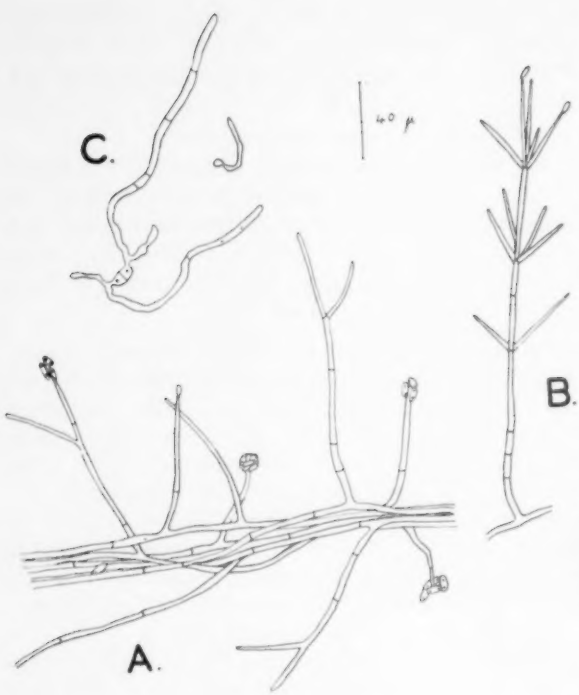

FIG. 7. Camera lucida drawing showing A) mycelial rope, bearing simple conidiophores, B) verticillate conidiophore from the same rope, and C) germinating 2-celled spore with 2 germ tubes.

pink colouration to the whole mycelium.

Normal cultures of *V. albo-atrum* often become hyaline after frequent subculturing. When this has happened, it is very difficult to induce the dark hyphae to reappear. This has been achieved with some success by transferring the hyaline mycelium to potato-dextrose agar. The hyaline variant described here did not, however, produce dark hyphae when grown on a potato-dextrose medium.

There is a marked similarity between this strain and *Verticillium intertextum* Isaac & Davies[3]. *V. intertextum* was isolated originally from a wilted Japanese maple tree in Massachusetts by Dr. M. A. McKenzie and described in England by Isaac and Davies. The hyaline variant of *V. albo-atrum* (Fig. 2) differs from *V. intertextum* in the size and shape of coremia and of phialospores, in the degree of pigment formation in daylight, and in its pathogenicity towards the tomato.[4]

FIG. 2. A mycelial rope of the hyaline variant of *Verticillium albo-atrum* photographed under the interference microscope. For assistance with the interference microscope the writer would like to thank Mr. K. F. A. Ross.

In this Department, several hyaline strains of *V. albo-atrum* have been isolated from tomato plants of the variety "Potentate" in which such strains can exist in the vessels without causing external symptoms. The hyaline variant described here, however, when stab-inoculated into tomato plants, produced wilting symptoms and foliar necrosis after 13 days. The pathogenicity of this hyaline strain is an important feature to consider when comparing this fungus with *V. intertextum* and with other hyaline strains of *V. albo-atrum*. —Department of Biological Sciences, Wye College, (University of London). Near Ashford, Kent, England.

[3] Isaac, I., and R. R. Davies. 1955. A new hyaline species of Verticillium: V. intertextum sp. nov. Brit. Mycol. Soc. Trans. 38 (Pt. 2): 143-156.

[4] Acknowledgement is made to Dr. A. H. S. Brown of the Commonwealth Mycological Institute for comparing the hyaline variant with *V. intertextum*.